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(Received 26 February 1984)

The paper deals with fecundity, oviposition period, duration of development, longevity and sex ratio of the parasitoidic wasp *Trioxys indicus*. Average fecundity of the parasitoid was 143 (as emergents) which is less in the presence of males. Most of the female parasitoids required 18 days for their complete development which is about one day more than that of males. Longevity of the female was greater than that of male. Survival of both the male and the female parasitoids significantly decreases in the presence of host. Sex ratio of the offspring is dependent on the maternal age.

(Key words: fecundity, oviposition period, longevity, sex ratio, *Trioxys indicus*, *Aphis craccivora)*

INTRODUCTION

Several aspects of the biology of *Trioxys (Binodoxys) indicus* have been dealt with elsewhere(PANDEY *et al* , 1983a). The present paper deals with the role of male on the fecundity, oviposition period, duration of development, longevity and sex ratio of the parasitoid, as the above information is important in the programming of biological control measures.

MATERIALS AND METHODS

In the laboratory, the technique of SINHA & SINGH (1979) was adopted for rearing of the aphid *A. craccivora* and the parasitoid *T. indicus* and the culture was maintained at 25 ± 2°C and 75 ± 1% RH. For the study of the fecundity and the oviposition period of the parasitoid 10 water-filled, marked, narrow mouthed, glass vials (60 ml) each containing a fresh cutting of *Cajanus cajan* Millsp. (Leguminaceae) with 10 almost equisized leaves (ca 6.5×2.0 cm) having ca 100 3rd instar nymphs of *A. craccivora* were arranged. Each vial was covered with a bell jar (25×15 cm). For food, a small piece of sponge soaked in 30% honey solution was suspended in the jars with thread through top opening. Thereafter freshly emerged (just emerged to 8 h old) and fully fed virgin (10 females and 10 males) were drawn from the culture (a pair in each test tube) and were allowed to mate. After mating all the 10 pairs of the parasitoid were segregated into two sets (each of 5 pairs). The first set of the parasitoids were introduced separately into 5 of the above mentioned belljars (a pair in each) for 24 h. Simultaneously, from the second set of the parasitoids, after the withdrawal of the males, the females were released for the same period, one in each of the remaining belljars. Finally the opening of the belljar was closed with muslin cloth tightened with rubber bands. After every 24 h the twigs of the host plant were replaced by fresh ones having about 100 hosts throughout the life-span of the parasitoid. The aphids with the twigs that were exposed for attack by the parasitoids were serially daywise placed in the insectaries and were examined daily. On the formation

of mummies they were picked off and transferred singly into marked glass vials (1×5 cm) having fresh leaf of the hostplant (for providing proper moisture to the developing parasitoids). The egressed parasitoids were recorded and sexed. 12 such series (2 sets of each) of the experiment were performed. Because of the chance of some superparasitoidism in the fields or egg-larval mortality, the emerging parasitoids have been considered as a better parameter of the fecundity (SINHA & SINGH, 1980).

The longevity of the mated females kept with or without males and with host have been studied from the above first and second sets of the experiments. Likewise, another experiment was also set up (in the presence or in the absence of male) but without hosts only with the host-plant.

RESULTS

The fecundity (in terms of emergents) of the parasitoid was observed in the presence and in the absence of male by recording the number of emergents egressed from the mummies. The presence of male significantly lessens not only the daily output but also the total fecundity of the parasitoid (Table 1). The mean fecundity of the female in the presence of male was 130 (7797 emergents yielded by 60 females) and in his absence was 143 (8574 emergents yielded by 60 females). The maximum number of the emergents yielded by a single female was 172 and the maximum oviposition period of *T. indicus* was of 8 days (3—8) which corresponds to their life-span (Table 1). The number of emergents obtained was maximum on the first day followed by a marked linear decrease ($Y = 34.6—4.1X$; $r = —0.99$ for inseminated females when kept with males and with hosts (IMH♀) and $Y = 41.3—5.2X$; $r = —0.99$ for inseminated females isolated from the males

TABLE 1. The fecundity (mean ± SD) and the oviposition period of inseminated female *T. indicus*.

Oviposition in successive days (oviposition period)	Fecundity (No. of emergents)		Cumulative fecundity	
	IMH♀ (n = 60)	IIH♀ (n = 60)	IMH♀	IIH♀
1	32.3 ± 5.4	38.9 ± 4.9*	32.3	38.9
2	25.3 ± 4.5	31.0 ± 4.0*	57.6	69.9
3	22.3 ± 2.6	23.0 ± 4.5*	79.9	92.9
4	18.4 ± 6.0	19.9 ± 3.7*	98.3	112.8
5	12.8 ± 5.2	14.2 ± 6.0*	111.1	127.0
6**	9.8 ± 5.6	9.3 ± 5.8^{+}	120.9	136.3
7	6.4 ± 5.6	5.5 ± 5.3^{+}	127.3	141.8
8	2.8 ± 4.4	1.3 ± 3.1^{+}	130.1	143.1

*P = 0.01; $^{+}$ not significant; ** The males died on 6th day morning (mean longevity = 4.55 ± 0.82 days)

and along with host (IIH♀) as the maternal age increases.

The developmental period of the female parasitoid was a day more than that of the males (Table 2). Mostly the female parasitoids require 18 days for their complete development. However, it varies from 15—21 days (Fig. 1); similarly the males take 17 days for their development (varies from 14—20 days). The period from oviposition to mummification (in both sexes) was greater than the period from mummification to emergence, although, majority of the females required 9 days for their development from oviposition to mummification and about 2/3 of the females emerged from the mummies on 9th and 10th days of their mummification (Fig. 1).

The longevity of the female parasitoid was greater than that of the male (Table 3). The presence of hosts significantly shortened the life-span of the parasitoid. However, the presence of male enhances the life-span of the female with host (Table 3). A contrary result is obtained regarding the longevity of the female in the absence of host (Table 3)

The sex ratio of the emergents is maternal-age-dependent ($F = 21.14$, $P < 0.001$). The highest proportion of the female was recorded from the oviposited eggs of the first two days

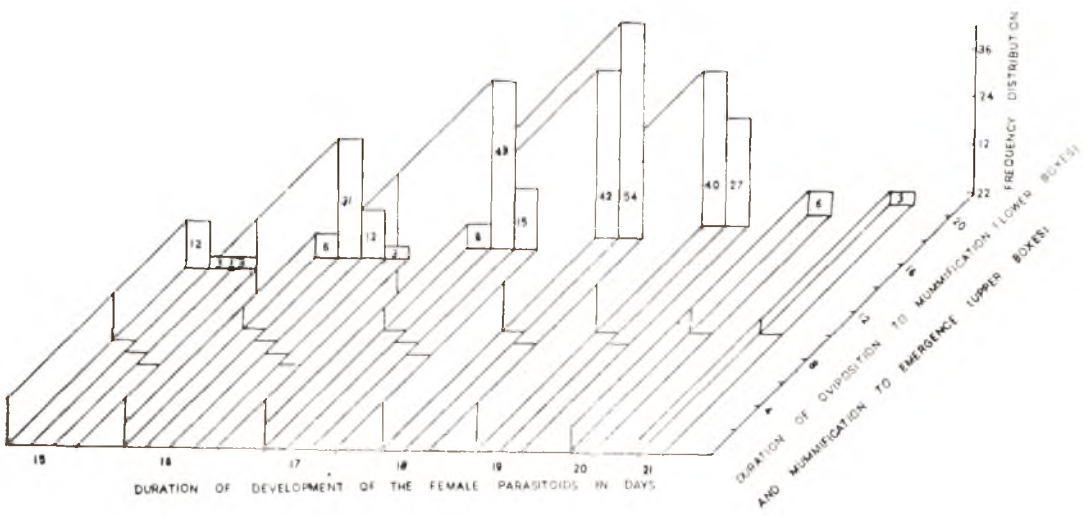

TABLE 2. The duration of development (mean ± SD days) of *T. indicus*.

Developmental stages	Female (n = 306)	Male (n = 119)	Significance of mean difference (t—test)
Oviposition to mummification	9.2 ± 1.06	9.0 ± 0.80	t = 1.91, P = 0.025
Mummification to emergence	8.6 ± 0.97	7.5 ± 0.98	t = 10.53, P = 0.001
Oviposition to emergence	17.8 ± 1.45	16.5 ± 1.25	t = 8.71, P = 0.001

TABLE 3. The longivity (mean ± SD days) of *T. indicus*.

Conditions		Female	Male
Mated parasitoids mixed with opposite sex (IMH♀)	Along with host (n = 60)	6.55 ± 1.39	4.55 ± 0.89[r]
	Without host	7.40 ± 2.15[c]	6.20 ± 2.19[rc]
Mated parasitoids isolated from opposite sex (IIH♀)	Along with host (n = 60)	6.10 ± 1.35	
	Without host (n = 60)	8.23 ± 2.06[c]	

Mean difference in rows (r) and in columns (c) are significant at P = 0.001.

(ca 75%). Later on, the eggs laid during 3rd and 4th days, and the proporation of females yielded were about 67%; then an equal proportion of male and female was recorded from the eggs laid on the 5th day; thereafter the male dominated over female up to 75% (Table 4).

TABLE 4. The sex ratio (percentage of females in the population) of *T. indicus* in two different experimental conditions.

Maternal age in days	Sex ratio of the offspring of IMH ♀	IIH♀
1	73.2 ± 4.2	78.5 ± 3.5*
2	71.1 ± 6.6	77.2 ± 3.9*
3	61.6 ± 6.6	68.2 ± 4.8*
4	57.0 ± 8.0	69.2 ± 4.7*
5	52.9 ± 8.7	54.0 ± 7.3[+]
6	44.2 ± 9.7	41.0 ± 8.9[+]
7	35.7 ± 7.2	29.4 ± 7.6*
8	35.8 ± 4.7	23.7 ± 9.7*
Mean	61·7	67.9

* Mean difference significant at P = 0.001

[+] Mean difference not significant.

DISCUSSION

Since the total number of eggs laid (realised fecundity) or all the eggs present in the ovaries (potential fecundity), either do not develop due to nonviabality of the eggs or superparasitoidism as in the former case or all the eggs are not laid as in the latter case, do not provide an adequate proportion of females available in the forthcoming generation for interacting with the hosts. Therefore, emphasis had been given to record either the number of mummies or emergents as the measure of fecundity among aphidiid parasitoids by earlier workers (HOFSVANG & HAGVAR, 1975a; SINHA & SINGH, 1980). In the present contribution the number of emergents had been considered as a better parameter of fecundity.

The average fecundity of the parasitoid was 130 (for IMH♀) and 143 (for IIH♀) per female which is very high in comparsion with other aphidiid wasps (STARY, 1970; HOFSVANG & HAGVAR, 1975a, b) whereas it is less than other aphidiids (CLOUTIER *et al.*, 1981). The fecundity of the aphidiids depends upon several extrinsic

and intrinsic factors *viz.*, temperature (MESSENGER, 1968), developing stages of the hosts (SINGH & SINHA, 1982), functional (HANDEY *et al.*, 1982) and numerical (SINHA & SINGH, 1980) responses of the parasitioid, host species preference (JACKSON *et al.*, 1974); nutrition of the parasitoid during its larval development (KUMAR *et al.*, 1983). The present investigation adds one more factor i.e., the presense of male along with ovipositing female which reduces her fecundity (Table 1).

The oviposition period is the time from the first to the last day of oviposition which corresponds with her life-span and ranges from 3—8 days (6.6 ± 1.4 SD days for IMH♀) and 4—8 days (6.1 ± 1.4 SD days for IIH♀) (Table 3). The oviposition pattern decreases linearly ($r = -0.99$ for IMH♀ and IIH♀). The presence of male significantly decreases the number of emergents (probably less number of eggs are laid) during the first five days and later on, after its death (on 6th day) no significant difference in the ovipositional activities was recorded (Table 1.)

The duration of development is the period from oviposition to emergence and seems to be influenced by several factors viz , photoperiod (MACKAUER & HENKELMAN, 1975), temperature (FORCE & MESSENGER, 1964), host species, parasitoid species and host-size (HOFSVANG & HAGVAR, 1975c); host-plants (SEKHAR, 1960). In *T. indicus* the period from mummification to emergence was shorter than the period from oviposition to mummification (Table 2, Fig. 1) like other aphidiids. The female parasitoid required significantly more time for mummification than the males: possibly the female requires more food for their proper development.

The longivity of the parasitoid is an important aspect of its life-history and depends upon several ecophysiological factors (STARY, 1970). On the whole, like other aphidiid wasps under similar ecophysiological condition *T. indicus* also survived for less than 10 days, although, a small percentage lived for more than 10 days. The longevity in the females is more than the males (Table 3).

The sex ratio of *T. indicus* gradually decreases with the increases of oviposition period (maternal age) from 73.2 to 35.8% for IMH♀ and 78.5 to 23.7% for IIH♀ (Table 4). These findings differ from the observations of HOFSVANG & HAGVAR (1975a, b); however, they reported a very low sex ratio. In aphidiids the sex ratio of the progeny is affected by a number of factors eg, the host-plant (RAMASESHJAH *et al.*, 1968), host age (CLOUTIER *et al.*, 1981), parental age (PANDEY *et al.*, 1983a), temperature (MESSENGER & FORCE, 1963), specificity of the parasitoid (HOFSVANG & HAGVAR, 1975a), post-copulatory period following inseminination (PANDEY *et al.*, 1983b), host and parasitoid densities (SINHA & SINGH, 1979) and virility of the male that inseminates the female (SINGH & SINHA, 1980). In addition, the presence of male, a condition met with in field had very little been studied as a factor influencing the sex ratio.

These findings indicate that *T. indicus* can be effectively used against *A. craccivora* by its release, as it has a high fecundity (5 times that of *A. craccivora*, RADKE *et al.*, 1973), oviposition period corresponding to her

lifecycle, and high sex ratio favouring female.

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AERODYNAMIC PARAMETERS AND DESIGN OF FLIGHT SURFACE OF MOSQUITO *ANOPHELES STEPHENSI*

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The paper describes 'System' in bioaerodynamics which comprises the flier and induced air, constitutes 'action-reaction pair' for the hovering flight. Hence the static and dynamic parameters of the flier *Anopheles stephensi* are determined. An expression for moment of inertia of the flight surface (wing) is deduced, considering wing design and geometry. Further, aerodynamic requirements in relation to flight performance are discussed.

(Key words: system, action-reaction pair, aerodynamic requirements, moment of inertia, hovering flight, flight surface)

INTRODUCTION

WEIS FOGH & JENSEN (1965) analysed the flight performance of locust by studying the physical principles involved in the flight. VOGEL (1966) studied the flight behaviour of *Drosophila*. PRINGLE (1968) reviewed the physiology of flight and kinematics of wings in insects. NEVILLE (1965) studied the power requirements in insect flight. ARAVINDA BABU *et al.* (1977) studied the aerodynamic parameters of *Chrysocoris purpureus*. ADEEL AHMAD (1978) did extensive work on aerodynamic parameters of different fliers and reported that a flier is conditioned by the basic aerodynamic problems. Thus a perusal of literature reveals that relatively little information exists about the aerodynamic requirements of *Anopheles stephensi* except a few reports on *Aedes aegyptii*. Recently wing vibrations of *A. stephensi* were analysed by SYED NAJMUL HASAN *et al.* (1983).

When a flier is in the state of hovering, it is said to be in the dynamical equilibrium which is achieved by the flier by generating the air induced downwards due to the wing beat in turn develops a reacting force, just to balance its body weight. The flier and induced air put together is considered as a 'system'. Thus in hovering flight the system constitutes an 'action-reaction pair' which helps the flier to be airborne.

In view of this, the authors have studied the static and dynamic parameters of the system (flier + air) and aerodynamic parameters of the flier. Further an expression is deduced for moment of inertia of the flight surface, considering the wing design and geometry.

MATERIALS AND METHODS

Mosquitoes, *A. stephensi* (Diptera : Culicidae) were collected from Musi river, Hyderabad and experiments were performed on 10 female and 10 male insects. An insect was allowed to hover in a glass chamber and the flight sound was recorded. Oscillograms were taken for the determination of wing beat frequency

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(SYED NAJMUL HASAN *et al.*, 1983). The dimensions of the body and wing were measured under the suitable magnification of dissecting microscope, using camara lucida. An analytical balance of least count 0.02 mg was used to determine mass of the flier and its wings. The wing stroke angle observed under the synchronised stroboscopic flash is about 60°. The area of the wings was determined by considering the expression, $A = \pi/C\ 4$, since the wings are approximately elliptical in shape (Fig. 1a). The same was verified by using a planimeter. Expressions for different parameters were derived, listed under 'Appendix'.

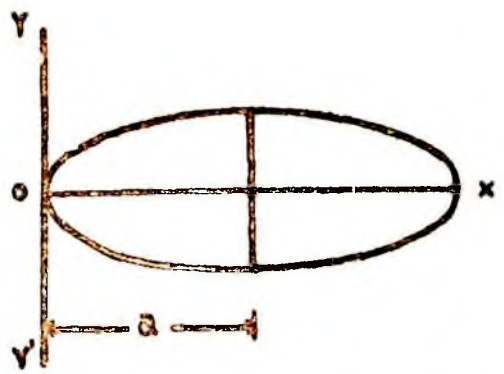

Fig. 1a Geometrical equivalence of the wing of *A. stephensi*.

Calculation of moment of intertia:

Observations on the wing movements under the stroboscopic flash show that wings vibrate about the axis YY', which is parallel to the body axis of the flier. The wing tip makes elongated 8 in the vertical plane with reference to the body plane and also there is buckling at the tip about the axis OX to a certain extent (Fig. 1b). To compute the moment of inertia of a body, the axis of rotation and uniform distribution of mass along that axis are the requisite parameters. Since the wing of the flier is very low in mass (0.02 to 0.04 mg) and size compared to the large size insects, the strip analysis is not possible to compute moment of inertia of the wing. But the mathematical expression can be deduced, since tha wings of *A. stephensi* are approximately elliptical in shape and

Fig. 1b Schematic equivalent wing diagram of *A. stephnsi* to compute moment of inertia.

che mass distribution in the wing is uniform (Appeedix). This method of theoretical determination of moment of inertia of an insect wing is similar to that of ADEEL HAMAD (1982).

RESULTS AND DISCUSSION

Table 1 shows the average static parameters of 8 male and 8 female *A. stephensi*. The mass, length, breadth fineness ratio of the flier, the span, length, area, effective breadth, mass, stroke angle, swept area, swept volume, disc area, arc length and arc length/chord length of the wing are considered as static parameters. These parameters differ in male and female *A. stephensi* mainly due to the variation in the body mass. The static parameters are essential to derive dynamic parameters of the system and aerodynamic parameters of the flier.

Table 2 gives the dynamic parameters like moment of inertia, angular velocity angular accelaration and angular momentum of the flight surface. Remarkable differences in these parameters of male and female insects are observed similar to the static parameters. The moment of inertia, the measure of the resistance a body offers to a change in the rotational motion about a given axis forms

the basis for the calculations of kinetic energy of the rotating body (wing). The moment of inertia of the flight surface of *A. stephensi* is in the range of 0.902×10^{-6} to 1.977×10^{-6} gm cm^2 which is less than those of large size insects. Table 3 reveals the data on the dynamic parameters-mass, rate of mass flow, acceleration, velocity and linear momentum of the induced air during the hovering flight. From Tables 2 & 3 it can be noticed that the velocity, acceleration, momentum of the flight surface and induced air bear definite relations which appear to be species specific. Table 4 presents the

TABLE 1. Static parameters of *A. stephensi*.

	Male		Female	
	Mean	± S D	Mean	± S D
Body mass X10^{-3} (gm)	1.95	0 18	3.02	0.467
Wing length (cm)	0 29	0.013	0 39	0.021
Wing span (cm)	0 70	0.029	0 89	0.051
Wing area (cm^2)	0.02	0.0009	0 027	0.0026
Effective wing breadth (cm)	0.071	0.0029	0.068	0.005
Length of the flier (cm)	0 57	0 058	0.46	0.052
Breadth of the flier (cm)	0.12	0.0158	0.096	0.010
Chord length (cm)	0.090	0.0043	0.103	0.0074
Wing mass X10^{-3} (gm)	0.03	0.0096	0.04	0.009
Disc area (cm^2)	0.38	0.074	0.631	0.068
Wing swept area (cm^2)	0.088	0.008	0.167	0.018
Wing swept volume X10^{-5} (cm^3)	6 29	0.517	11.51	1.582
Fineness ratio	4.36	0.498	4.99	0.809
Arc length (cm)	0.30	0 013	0 419	0.0225
Arc length/chord length	3 3	0.25	4 1	0.26

TABLE 2. Dynamic parameters of *A. stephensi*.

	Male		Female	
	Mean	± S D	Mean	± S D
Moment of inertia X10^{-3} (gm cm^2)	0.902	0.326	1.977	0.203
Angular velocity (rad/sec)	1821	171	1689	218
Angular acceleration X10^3 (rad/sec^2)	6394	123	5539	143
Angular momentum X10^{-3} (rad gm cm^2/sec)	1.625	0.0593	3.34	0.0558
Kinetic energy (erg)	1 20	0.612	2.86	0.80

TABLE 3. Dynamic parameters of air induced by *A. stephensi.*

	Male		Female	
	Mean	± S D	Mean	± S D
Rate of mass flow X10^{-3} (gm/sec)	1.85	0.18	3.64	0.685
Mass X10^{-5} (gm)	0.688	0 058	1.266	0.173
Acceleration (cm/sec^2)	53624	4902	46580	8142
Velocity (cm/sec)	98.87	2.8	90.3	5.8
Kinetic energy X10^{-2} (erg)	3.36	0 28	5.10	0.45
Momentum X10^{-3} (gm cm/sec)	0.678	0.053	1.1	0.13

TABLE 4. Aerodynamic parameters of *A. stephensi.*

	Male		Female	
	Mean	± S D	Mean	± S D
Aspect ratio	4.1	0.30	5.84	0.50
Wing loading (gm/cm^2)	0.093	0.009	0.052	0 011
Disc loading (gm/cm^2)	0.005	0 0005	0.0046	0 0002
M_w/M_t	0 016	0 0038	0.026	0.001
Frequency of wing beat (Hz)	520	65	475	30

data on aerodynamic parameters such as aspect ratio, wing loading, disc loading wing mass/body mass and wing beat frequency of the flier. Wing loading is of the order 0.048 to 0.1 gm/cm^2 thereby indicating a relatively high wing area in relation to the mass of the flier. The wing loading values in insects are usually low as compared to birds and bats. The study of Table 4 suggests that *A. stephensi* possesses relatively high aerodynamic efficiency contributing a greater lift and thrust. The disc loading of both male and female *A. stephensi* is more or less the same. Aspect ratio of male and female *A. stephensi* is in the range of 4 to 6.6 suggesting that the manoeurability is relatively higher in females. Due to higher aspect ratio than other insects, *A. stephensi* can have high power economy and hence can hover for a considerable duration. Wing mass/body mass is a tool to decide the metabolic rate of the flight machinary. This ratio is 0.001 in males and 0.002 in females. These values are in agreement with those of other insects but remarkable deviation is observed in the case of some large (0.04—0.07) and small (0.03—0.04) birds (ADEEL AHMAD, 1978). The high frequency of wing beat of the myogenic flier, *A. stephensi* is discussed earlier by the authors (SYED NAJMUL HASAN *et al.*, 1983). Thus the present results throw light on the characteristic

APPENDIX

M_f = Mass of the flier (gm)

l_w = Lenghth of the wing, (cm)

L = Span of the wing, (cm)

A_w = Area of the wing (single), (cm^2)

B_{eff} = Effective breadth of the wing = A_w / l_w, (cm)

l_f = Length of the flier, (cm)

b_f = Breadth of the flier, (cm)

C = Chord lenght, (cm)

M_w = Mass of the wing, (gm)

ϕ = Stroke angle, (rad)

S_d = Area of the wing disc = $\left(\frac{\pi L^2}{4}\right)$, ($cm^2$)

S_w = Wing swept area = $(1/3)(\pi l^2)$, (cm^2)

V_w = Wing swept volume = $(1/3)(\pi l^2 B_{eff})$, (cm^3)

I = Moment of inertia of the wing = $(5/16)(M_w l^2)$, (gm cm^2)

ν = Frequency of wing beat (Hz)

ω = Angular velocity of the wing = $(1/3)(\pi^2 \nu)$, (rad sec^{-1})

α = Angular acceleration of the wing = $(2/3)(\pi^3 \nu^2)$, (rad sec^{-2})

B_w = Angular momentum of the wing = $I\omega$, (gm cm^2 rad sec^{-1})

z = Arc length = $(1/3)(\pi l)$, (cm^2)

γ = Fineness ratio = l_f / b_f

λ = z / c

AR = Aspect ratio = l^2/A

ρ = Density of air = 1.1×10^{-3} (gm cm^{-3})

dm/dt = Rate of mass flow of air = $S_w B_{eff} \rho \nu / 2$ (gm sec^{-1})

m_a = Mass of the induced air = $S_w B_{eff} \rho$ (gm)

v_{iz} = Velocity of induced air = $(M_f g)^{1/2} / (2 S_w \rho)^{1/2}$, (cm sec^{-1})

a_{iz} = Acceleration of the induced air = $v_{iz} \nu$, (cm sec^{-2})

K_a = Kinetic energy of induced air = $(1/2)(m_a v_{iz}^2)$, (erg)

P_a = Momentum of induced air = $m_a v_{iz}$, (gm cm sec^{-1})

WL = Wing loading = $M_f / (A_w)$, (gm cm^2)

DL = Disc loading = $M_f / (S_d)$, (gm cm^2)

differences in the design and function of the flight surface and the aerodynamic parameters of the flier may explain the flight abaptattions of the dipteran flight.

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CHANGES IN PROTEIN METABOLISM IN THE MIDDLE AND POSTERIOR SILK GLAND TISSUE OF ERI-SILKWORM, *PHILOSAMIA RICINI*, IN RELATION TO THE SPINNING PROCESS

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The middle and posterior portions of the silk gland of eri-silkworm demonstrate a tendency for consistent increase in their total free amino acid, protein and RNA concentrations, reaching the maximal level just prior to spinning of the cocoon. However, a higher biosynthetic status was observed in the posterior part of the gland than that in the middle one.

(Key words: biochemical changes, silk gland, eri-silkworm, spinning)

INTRODUCTION

The only function of the silk gland of a silkworm is to synthesise the proteins needed for the silk formation. Therefore, the silk gland metabolism necessarily involves the protein metabolism to a large extent during the growth and degeneration of the gland in relation to the spinning process (CHINZEI & TOJO, 1972; OKABE *et al*, 1975; PANT & UNNI, 1978; SINGH & SINGH, 1978). However, such information is based on the findings on the whole silk gland homogenate including the native liquid silk present in it. The results so obtained may lead to erroneous conclusions regarding the role played by the silk gland tissue. Moreover, the gland itself is divisible into anterior, middle and posterior portions with particular functions of their own (KURATA *et al*, 1974; SRIDHAR *et al*, 1977). Hence, the present investigation was planned to find out the changes in certain biochemical parameters of protein metabolism in the middle and posterior silk gland tissues separately (excluding the liquid silk) in the eri-silkworm, *Philosamia ricini*, in relation to the spinning process.

MATERIALS AND METHODS

The rearing of the eri-silkworms and the removal of their silk gland was done in accordance with the method described by SINGH & SINGH (1978). The middle and posterior portions of the silk gland were separated and placed in ice-cold distilled water for half an hour when the native liquid silk was extruded out of the silk gland (SHIMADA & HAYASHIYA, 1975). Each tissue portion of the silk gland was then used as the tissue sample. The tissue fractionation for total free amino acid, protein, RNA and DNA and their quantitative measurements were made according to the procedures already reported by SINGH & SINGH (1978).

RESULTS AND DISCUSSION

The middle and posterior silk gland tissues exhibit almost similar changes

with respect to the parameters studied during the growth of the 5th instar and the spinning period (Figs. 1, 2). However, the absolute values for the total free amino acid and protein concentrations are much lower than the values given by SINGH *et al.* (1979) for the whole silk gland. It is because the liquid silk has been excluded in the present work.

All the biochemical parameters studied in both portions of the silk gland tissue demonstrate a tendency of consistent increase upto a maximal level towards the end of the 5th instar (Figs. 1, 2). The enhancement in the protein concentration of the middle part of silk gland tissue (Fig. 1) is about twice when a comparison is made between the values observed on the first day and the last day of the 5th instar whereas it is more than three-fold in case of the posterior silk gland tissue (Fig. 2). This clearly demonstrates a higher level of biosynthetic status of the posterior tissue than that of the middle part of the silk gland. It can be correlated with the higher demand for fibroin synthesis than for sericin according to their composition of the silk fibre (70—75% and 20—25% respectively). This also corresponds with the tenfold increase in tRNA species in the fibroin part (posterior tissue) of the silk gland, as reported by CHAVANCY *et al.* (1971) in *Bombyx mori*. The increased level of protein concentration in the middle and posterior silk gland tissues towards the end of the 5th instar as observed in the present investigation is in conformity with the reports made by DE TURENNE & DAILLIE (1973 a, b) and KURATA *et al.* (1974) regarding the massive silk synthesis towards the end of the 5th instar of *Bombyx mori*.

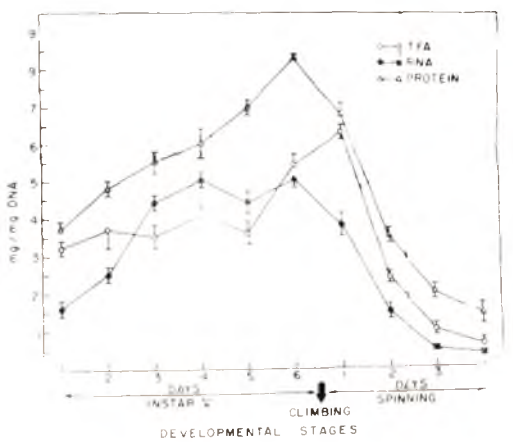

Fig. 1. Changes in the levels of TFA, RNA and protein in the middle silk gland tissue of eri-silkworm in relation to spinning process (Mean of 5 replicates ± S D).

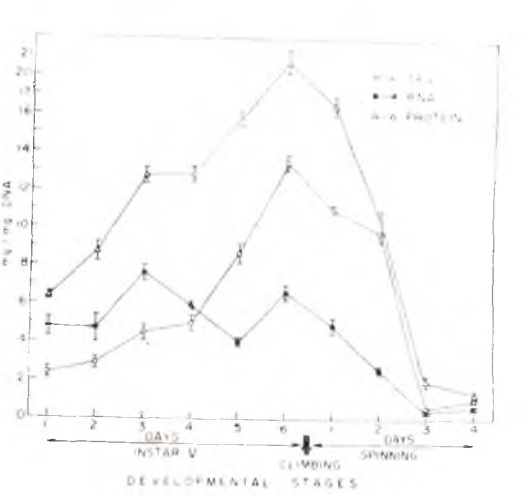

Fig 2. Changes in the levels of TFA, RNA and protein in the posterior silk gland tissue of eri-silkworm in relation to spinning process (Mean of 5 replicates ± S D).

Both middle and posterior silk gland tissues demonstrate two peak values of their RNA/DNA ratio, one in the middle period while the other at the end of the 5th instar. Almost similar two peak

levels in the RNA/DNA ratio of the silk gland in the 5th instar of *B. mori* have been reported by KURATA *et al.* (1974). Thus, the similar results in eri-silkworm confirms the hypothesis of KURATA *et al.* (1974) that "the amount of RNA in the silk gland is an important factor and probably regulates the fibroin synthesis." The two peaks in RNA/DNA ratio of the middle and posterior silk gland tissues during the 5th instar larval growth, as observed in the present investigation, are probably in response to the increased RNA polymerase activity as reported by SRIDHAR *et al.* (1977) in the silk gland of *B. mori* during the early and again in the later part of the 5th instar.

A high level of total free amino acids in the middle and posterior silk gland tissues just prior to spinning is in response to the high demand of incorporation of these precursors into sericin and fibroin synthesized in the two parts of the gland respectively. CHITRA & SRIDHAR (1972) also observed a significant increase in the total free amino acids of the whole silk gland of *B. mori* towards the end of the 5th instar. The remarkable enhancement in the level of total free amino acids and RNA in both the tissue portions of silk gland towards the later period of the 5th instar, as reported here, may also be correlated with the high demand of structural proteins needed for the massive growth of the glands themselves,

The commencement of spinning process is characterized by a sharp decrease in all the biochemical parameters measured in both the parts of silk gland tissue. However, the total free amino acid titre of the middle silk gland tissue gets further increased on the first day of spinning process, probably because of cessation of protein synthesis by the time. A higher level of protein concentration in the silk gland tissue even on the last day of the 5th instar as reported earlier by SINGH & SINGH (1978), but not observed in the present investigation, was certainly due to the fact that the previous workers used the whole silk gland including the liquid silk (which is maximally accumulated at the time of the commencement of spinning process).

The levels of all the biochemical components in the middle and posterior silk gland tissues are at their minimum on the last day of spinning process, beyond which the whole silk gland dwindles away. MATSUURA *et al.* (1968) also reported a similar decrease in the amount of RNA and protein of the silk gland of *Bombyx mori* during the spinning process. However, the rapid decrease in the amount of RNA did not result in the accumulation of their degradation products in the tissue, which were possibly eliminated out without complete decomposition as suggested by OKABE (1975).

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SEASONAL DENSITY AND NATURAL SURVIVAL RATE OF FILARIASIS VECTOR *CULEX QUINQUEFASCIATUS* (DIPTERA: CULICIDAE) IN GURGAON, NORTHERN INDIA.

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The seasonal density and survival rate of *Culex quinquefasciatus* in open environment was observed in Gurgaon city from Jan. — Dec. 1980. The highest larval density (2.17 per dip) was recorded in November and 2.16 per dip in April. The highest adult man-hour density (32.7) was recorded in April. The highest survival rate of 84.54 percent occurred in hot month of May.

(Key words: density, survival rate, *Culex quinquefasciatus)*

INTRODUCTION

In spite of scientific advances, it has not yet become possible to effectively control certain tropical diseases whose causal agents are transmitted by one or more arthropod species. In the case of some of these diseases the situation has become worse. This applies to bancroftian filariasis, whose incidence is increasing every year. *Culex quinquefasciatus* plays a major role in the transmission of bancroftian filariasis, (SUBRA, 1980). In Africa its prevalance may well extend filariasis transmission to all the cities in South of Sahara (HAMON, 1967). *Culex quinquefasciatus* seems capable of invading the whole environment in town or country as a result of changes caused by the habit of population and various aspects of modern life (SUBRA & HEBRARD, 1975). In Pondicherry, MENON & RAJAGOPALAN (1981) studied the seasonal changes of this species. PAL *et al.* (1960) studied the bionomics of vectors of human filariasis in Eranakulam (Kerala). Entomological aspects of filariasis in East Godavari District (Andhra Pradesh) was studied by RAO *et al.* (1981). Seasonal changes in larval habitats and population density of *Culex fatigans* was observed in Delhi village by YASUNO *et al* (1973). RAJAGOPALAN *et al.* (1976) observed the estimation of natural survival rates in Faridabad. Although many ecological studies have been made in the past on *Culex quinquefasciatus*, knowledge of certain aspects of its life-cycle and ecology is limited. As such factors appear to operate more strongly during the larval stages, they consitute an essential factor to be studied since they relate to the application of any control method. Due to rapid urbanization and sanitation problems *Culex quinquefasciatus* occurs in high densities in Gurgaon. The present study was carried out to study the survival rate and seasonal changes in the natural breeding and adult population of *Culex quinquefasciatus* in Gurgaon urban.

MATERIALS AND METHODS

Study site: The study site (Gurgaon city Haryana state) is an urban environment with a population of 1,11171. Drains are the

most important breeding sites for *Culex quinquefasciatus*. Daily introductions of garbage, human waste and domestic wash water make them unstable. The water surface is seldom clear for debris. They often blocked during the dry season. High larval densities occur throughout the year. At the periphery of the town, new colonies are developing under Haryana Urban Development Authority (HUDA). So house tanks are also served as good breeding place for *Culex quinquefasciatus*. The town is divided into different residential localities and sectors. In the interior of city, houses are located in rows on either side of streets, with effluent drains located between the roads and the row of houses. Timely water is supplied by Municipal Committee. All the localities and sectors of the city have identical ecological condition. The expansion of city is unplanned in the sense that none of the new colonies have any sewage.

The city was divided into six sectors for entomological observation. In each sector there were five fixed and five random capturing stations for immatures. Eight catching stations were fixed in each sector for adult population. The collection was made by one Insect Collector spending 15 minutes in each catching station with aspirator tube and torch light. Laddle was used for larval collection and density was recorded as per dip. Survival rate were recorded in winter (December and January), spring (February and March), summer (April, May and June) and the monsoon (July, August and September).

RESULTS AND DISCUSSION

The sector-wise larval densities of *Culux quinquefasciatus* in different months are shown in Table 1. Seasonal adult resting density is summarized in Table 2. A marked difference in survival rate was observed in different seasons (Table 3). The highest positive breeding (28.64%) was recorded in the month of July. The highest larval density (2.17 and 2.16

TABLE 1. Seasonal larval density of *Culex quinquefasciatus*.

Month (1980)	No. of total dips	Total water collection checked	Found positive		% positive	Density per dip					
						Sectors					
			F	R		1	2	3	4	5	6
Jan.	1150	230	16	19	15 22	0.58	0 59	0.35	0.19	0.15	0.33
Feb.	1150	230	23	20	18.70	0.54	0.57	0.47	0 25	0.31	0.48
Mar.	1000	200	23	20	22	1.46	1.17	0.35	0.41	1.90	0.31
Apl.	1200	240	18	36	22.50	2.16	1.10	1.55	1.80	1.80	1.28
May	900	180	11	25	20	1.85	0 13	1.13	1.30	0.35	1.21
June	1100	220	06	34	18.18	1.32	1.80	1.21	0.48	0.40	1.11
July	1100	220	07	56	28.64	0.37	0.19	1 15	1.30	0 14	0 29
Aug.	1100	220	08	48	25.45	1.07	1.65	1.33	0.95	1.15	1.19
Sept.	1100	220	2	20	10	1.12	nil	0.70	nil	nil	0.80
Oct.	900	180	9	27	20	1.60	1.13	1.65	1.45	1.50	1.85
Nov.	1000	200	9	24	16.50	2 60	1.55	1.97	0.47	0.43	2.17
Dec.	1250	250	6	20	10.40	1.56	0 24	1.30	0.87	0 32	0.18

F = Fixed larval catching station. R = Random larval catching station.

TABLE 2. Seasonal resting adult density of *Culex quinquefasciatus*.

Month (1980)	NFCP	NRCP	Total time spent (hours)	D/MH Sectors					
				1	2	3	4	5	6
Jan.	110	66	44	9	11.7	9.9	5.5	5.5	9.7
Feb.	120	72	48	6.75	9	7.9	4.2	7.4	9
Mar.	100	60	40	18.26	12.6	10.7	11.3	18.8	14.3
Apl.	120	72	48	28.3	25.7	29.5	28.20	32.7	31.12
May	100	60	40	21.50	9.20	5.3	13.7	13.7	26.4
June	115	69	46	13.5	12.7	6.6	10.8	10.7	25.2
July	115	69	46	15.8	5.8	9.1	15.9	11.1	16.1
Aug.	140	66	44	22.7	13	15.3	18.5	16.7	22.2
Sept.	105	63	42	14.4	11	14.5	13.5	7.7	20.2
Oct.	40	54	36	29	14.3	15.5	20	19.6	24.5
Nov.	100	60	26	18.6	17	13	16.3	16.3	19
Dec.	125	75	50	13	10.4	11.2	16.3	13.5	15.7

NFCP = No. of fixed capture station. NRCP = No. of random capture station
D/MH = Density per-man hour.

per dip) was recorded in November and April in sector 6 and sector 1 respectively. The peak density for adult was observed in April (32.7 per man hour) in sector 5. The highest survival rate obtained was 84.54% in May when natural population is on increase. The survival rates were observed during the monsoon season comparatively, high survival rate was also seen in winter season with the maximum (51.43%) in January. MENON & RAJAGOPALAN (1981) also observed relatively high survival for *Culex pipiens fatigans* in the winter season in Pondicherry. In September and October when rainfall decreased, the survival rate recorded over August. The similar type of survival rate was also recorded in Delhi villages by RAJAGOPALAN *et al.* (1976). It was found that the develop mental time changed appreciably with the season. It is also evident from Table 2 that highest resting adult density was recorded in the month of April in all sectors. As the changes observed in larval and pupal density closely corresponded to changes in adult density.

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TABLE 3. Seasonal survival rate of immatures *Culex quinquefasciatus* in natural breeding.

Season (1980)	No. of larvae	No. of pupae	Survival rate %
Winter			
Dec.	1479	639	43.20
Jan.	453	235	51.43
Spring			
Feb.	514	226	43.97
Mar.	1036	444	42.86
Summer			
Apl.	2036	858	42.22
May	1164	984	84.54
June	1313	227	17.28
Autmn			
Oct.	1522	566	36.53
Nov.	1516	768	50.66
Monsoon			
July	1419	159	11.21
Aug.	1369	795	58.07
Sept.	715	428	59.86

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SEASONAL DENSITY OF MALARIA VECTOR *ANOPHELES CULICIFACIES* (DIPTERA : CULICIDAE) IN RELATION TO EPIDEMIOLOGICAL ASSESSMENT

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The seasonal density of malaria vector *Anopheles culicifacies* was observed from May, 1983 to February, 1984 in Gurgaon city. Monthly changes in larval density were recorded and highest density (3.3 per dip) observed in September, 1983. Peak density of adult vector (4.2 per man-hour) were recorded in September, 1983. Slide positivity rate (SPR) was highest in June (3.49%) for malaria parasite. Slide falciparum rate (SFR) was high in October and November, 1983. The highest positive breeding for *Anopheles culicifacies* were observed in Nala (56.5%).

(Key words: Malaria, density, breeding)

INTRODUCTION

The importance of an anopheline species as a vector of malaria depends on several characterstics that should be considered together. The density of the vector population, it's susceptibility to infection, life span and probability of feeding on man are of obvious significance. These characterstics affect the vectorial capacity of the vector, but other variables should also be taken into account in the selection of control measures eg., the type and number of mosquito breeding places and resting density (WHO, 1979). *Anopheles culicifacies* is the most important vector of malaria in India. Gurgaon city has been endemic for malaria for a long time. There was reduction in malaria cases upto 1975 but thereafter in 1976, 4252 cases of malaria were recorded in the city. It was clear that transmission continued in the city. So studies were undertaken to obtain information about seasonal density of *Anopheles culicifacies* in relation to malaria transmission between May, 1983 and February, 1984 in Gurgaon city.

MATERIALS AND METHODS

Gurgaon city is situated 35 km from Delhi having 15 sq km area. The population dur ng study was 1,11,995 of the city. For epidemiological and entomological studies the city was divided into six sectors. Each sector was surveyd by one insect collector for larval and adult eensity of *Anopheles culicifacies*. The larval collection was carried out between 9.30 AM to 11.30 AM with a laddle. In each sector ten capturing stations were made for larval collection. Larval density was recorded as density per dip. The adult mosquito collection was carried out between 6 AM to 8 with AM using aspirator tube and torch light. Collections were made from eight catching stations in each sector at weekly intervals. The mosquitos were also collected in human dwelling, cattle shed and mixed shed spending fifteen minutes per capture station resulting in a sample of 2 man-hours. Adult density was recorded as density per man-hour. Every temporary and permanent water collection

was surveyed for larval breeding in different months. The breeding sites consisted of pits, drains, house tanks, ponds, nala and disposal tanks. As the community has undergone urbanization and new sectors developed by Haryana Urban Development Authority, the temporary house tanks also served a breeding source for *Anopheles culicifacies*. The malaria positive cases were reported in each sector after examining the total blood slides. Cases of fever were also recorded from Civil Hospital and District Malaria Clinic. All the blood slides were examined for *Plasmodium vivax* and *Plasmodium falciparum* parasite. Slide positivity rate (SPR) and slide falciparum rate (SFR) were also recorded seprately. Seasonal prevalance of malaria parasites in each sector was also reported in dry and wet months. The statistical methods have been used, following SWAROOP (1966). Malariometric surveys were carried out as mentioned by BLACK (1968). Larval and adult mosquito density were calculated by using the standard method of WHO procedure (1975).

RESULTS AND DISCUSSION

Meteorological data recorded during the study are given in Table 1. The highest mean maximum temprature recorded during the study was 33.8°C in May, 1983 and the lowest mean minimum temperature 13.5°C in Jan. 1984. Maximum rainfall was recorded in July 1983. Humidity was lowest (78.5%) in May 1983. The fluctuations in the breeding status in different habitats and larval density in different months are shown in Table 2. The highest positive breeding were observed in nala (56.5%) in May 1983. Drains and pits were also good breeding habitats. The lowest percentage of larval breeding observed in ponds of the city. In November and December, 1983 no breeding was observed in ponds. The larval density also fluctuated every month and highest larval density (3.3 per dip) was recorded in September, 1983. Seasonal adult density, malaria parasite incidence, slide positivity rate and slide falciparum rate are given in Table 3. The peak density of *Anopheles culicifacies* (4.2 per man-hour) was recorded in September. Density was zero in January and February 1984. *Plasmodium vivax* showed a peak during October and *Plasmodium falciparum* was also highest (10) in the same month. Higher incidence of *Plasmodium vivax* was observed during June to October. Sector-wise distribution of malaria cases are shown in Table 4. In wet season *Plasmodium vivax* was highest in sector 2.

TABLE 1. Monthly maximum and minimum temperatures, rainfall and humidity in Gurgaon city.

Month (1983–84)	Mean Max. °C	Mean Mini. °C	Rainfall (mm)	Humidity %
May	33. 8	25.9	85.5	78.5
June	32.3	28.5	54.5	80.2
July	31.8	30.2	476.5	78.8
Aug.	30.07	27.5	44.5	81.7
Sept.	30	21.5	178.5	83.6
Oct.	27.4	21.8	nil	83.6
Nov.	20.9	14.4	nil	94.5
Dec.	15.9	11.3	nil	92.3
Jan.	13.5	8.9	nil	85.5
Feb.	26.35	18.6	5	89.4

In this study it is clear that vector density is directly correlated with malaria incidence. The highest larval and adult density was recorded in the month of September and malaria incidence also highest in the month of September and October. CHAUDHARY *et al.* (1983) also observed the exact similar type of

TABLE 2. Seasonal changes in immatures density and different type of water collection found with breeding for *A. culicifacies*.

Month (1983-84)	Total water collection	% Positive habitat					Density per dip
		Pit	Pond	Drain	Tank	Nala	
May	220	24.5	7.1	27.7	38.4	56.5	1.1
June	200	26.5	6.8	22.5	28.5	41.1	1.5
July	280	6.9	nil	14.6	16	28.5	0.7
Aug.	150	29.4	10	17.6	13.3	21.4	3.1
Sept.	170	41.5	11.2	10	37.9	35.2	3.3
Oct.	190	25.7	9.3	27.5	35.4	47.6	2.2
Nov.	190	20.2	nil	30.5	25.7	44.4	1.2
Dec.	260	18.8	nil	14.6	14.2	20	0.5
Jan.	200	12.2	11	7	8.8	0.5	nil
Feb.	210	8.3	1.9	9.1	3.7	14.2	nil

TABLE 3. Seasonal density of *Anopheles culicifacies* in relation to malaria incidence.

Month (1983-84)	NFCP	NRCP	Time spent (Hours)	Density per man-hour	Malaria parasite		SPR (%)	SFR (%)
					P. vivax	*P. falciparum*		
May	110	66	44	1.1	11	nil	1.09	nil
June	100	60	40	1.8	41	nil	3.49	nil
July	135	81	57	0.6	46	nil	3.13	nil
Aug.	75	45	30	2.5	36	nil	1.54	nil
Sept.	85	51	34	4.2	58	nil	1.53	nil
Oct.	95	57	38	2.1	82	10	2.53	0.28
Nov.	95	57	38	1.2	17	4	0.89	0.25
Dec.	130	78	52	0.3	9	3	0.43	0.14
Jan.	100	60	40	nil	4	1	0.24	0.02
Feb.	105	63	42	nil	1	nil	0.03	nil

NFCP = No. of fixed capture station. NRCP = No. of random capture station.

TABLE 4. Sector-wise seasonal variation of malaria parasite in different seasons.

Parasite	Season 'A'	Sector						Total
		1	2	3	4	5	6	
Plasmodium vivax.	Dry	6	4	5	4	6	7	32
	Wet	46	52	43	46	50	38	275
Plasmodium falciparum	Dry	1	2	1	1	1	2	8
	Wet	2	1	1	1	2	3	10

A. Total rainfall of *5 mm* for dry months (Nov. 83—Feb. 1984) compared with *453.5 mm* for wet months (May 1983—Oct '83)

transmission in Nainital District. This type of transmission was also observed by SHARMA *et al.* (1983) in Haryana state. The importance of this study was underscored by the fact that spray operations are required at the time of seasonal peaks of mosquito vector and malaria incidence. In Haryana state, there was significant increase of falciparum malaria during 1976—1977 and signal was founded by RAY (1979). The study also showed that incidence of falciparum malaria was low and that this was most opportune time to eradicate it.

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INFESTATION AND HOST SPECIFICITY OF *LIRIOMYZA BRASSICAE* RILEY AND THE ROLE OF PHENOLIC COMPOUNDS IN HOST PLANT RESISTANCE*

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The paper contains the rate of infestation by *Liriomyza brassicae* Riley on four economically important host plants viz., *Brassica compestris* L., *Pisum sativum* L., *Tropaeolum majus* L. and *Lathyrus odoratus* L. for three consecutive growitg seasons, 1978-1979, 1979-1980 and 1980-1981. Phenolic content in the leaves of the above four plants are correlated with the extent of infestation.

(Key words: infestation, host specificity, *Liriomyza brassicae*, phenolic compounds, host-plant resistance)

INTRODUCTION

Plant resistance against insect attack is of paramount importance in increasing the crop yield and minimising the pest population. The larval stages of *Liriomyza brassicae* Riley (a leaf miner) cause extensive damage to the leaves of *Brassica campestris* L., *Pisum sativum* L, *Tropaeolum majus* L. and *Lathyrus odoratus* L. The larvae feed on the green mesophyll tissue (mainly palisade) and consequently reduce the amount of green pigment, thereby affecting the yield of photosynthesis. The infested leaves turn yellow and premature fall results.

Chemical control of the larval feeding stages of Agromyzids has not been effective because of its mining habits. The larvae remain inside the mine in the sub-epidermal tissue of the plant part they feed. During present studies the amount of phenolic compounds in the leaves of the four selected economically important host plants were determined and correlated with the rate of infestation to find out the preference and host-specificity of this fly and the possible role of this chemical in the resistance of these host plants.

MATERIALS AND METHODS

Regular field surveys were undertaken to collect infestation data on these host plants. To work out the percentage of plant infestation, 100 plants were examined at random and the number of infested and non-infested plants were noted. To find out the rate of leaf infestation, the total number of leaves and the number of infested leaves were recorded in a total of 25 plants and the percentage was calculated. Appearance of one or more mines on a single leaf was taken as infested leaf. In case of *Pisum sativum* L. and *Lathyrus odoratus* L. the leaves are compound and divided into leaflets. In these cases the appearance of mine on a leaflet was considered as the infestation of the parent leaf. The identification of *Liriomyza* mine from other Agromyzids was made on the basis of mining pattern, distribution pattern of the frass particles (excreta) inside the mine and also the characteristics of the adults after emergence. Tables 1, 2, 3 and 4

* Contribution No. 287, from the School of Entomology, St. John's College, Agra.

TABLE 1. *Liriomyza brassicae* Riley on *Brassica campestris* L.

Growing season	Plant infestation				Leaf infestation				
	No. of plants examined	No. of infested plants	Infestation %	Average	No. of plants examined	Total No. of leaves	No. of infested leaves	Infestation %	Average
1978—1979	4800	2641	55.02		1200	82415	15017	18.22	
1979—1980	4600	2636	57.30	55.77%	1150	78853	14766	18.73	18.66%
1980—1981	4100	2254	54.98		1025	71088	13533	19.04	

TABLE 2. *Liriomyza brassicae* Riley on *Pisum sativum* L.

Growing season	Plant infestation				Leaf infestation				
	No. of plants examined	No. of infested plants	Infestation %	Average	No. of plants examined	Total No. of leaves	No. of infested leaves	Infestation %	Average
1978—1979	4800	2460	51.25		1200	99045	15366	15.51	
1979—1980	4600	2352	51.13	50.46%	1150	95781	15201	15.87	16.14%
1980—1981	4100	2009	49.00		1025	81132	13829	17.05	

TABLE 3. *Liriomyza brassicae* Riley on *Tropaeolum majus* L.

Growing season	Plant infestation				Leaf infestation				
	No. of plants examined	No. of infested plants	Infestation %	Average	No. of plants examined	Total No. of leaves	No. of infested leaves	Infestation %	Average
1978—1979	4800	1673	34.85		1200	28080	3112	11.08	
1979—1980	4600	1722	37.43	35.45%	1150	26476	3161	11.94	11.77%
1980—1981	4100	1397	34.07		1025	23159	2847	12.29	

TABLE 4. *Liriomyza brassicae* Riley on *Lathyrus odoratus* L.

Growing season	Plant infestation				Leaf infestation				
	No. of plants examined	No. of infested plants	Infestation %	Average	No. of plants examined	Total No. of leaves	No. of infested leaves	Infestation %	Average
1978—1979	4800	1012	21.08		1200	67999	4582	6.74	
1979—1980	4600	1035	22.50	21.66%	1150	65937	4392	6.66	6.95%
1980—1981	4100	877	21.39		1025	58542	4367	7.46	

contain the observations on the incidence of infestation on the four selected host-plants collected during three growing seasons. The average rate of infestations has been calculated at the end of three seasons in case of each host plant.

Estimation of phenolic compounds content is done on a simple filter type electric colorimeter by the method of BHATIA *et al* (1972). The leaves being the site of infestation, were collected (non-infested portions), dried in shade, powdered in a glass tissue grinder and 100 mg of the dried sample in case of each host-plant was extracted with 5 ml methanol in a stoppered conical flask for one hour with intermittent shaking. The supernatant was removed and the process was repeated twice. Mostly phenols are readily soluble in organic solvents, but to ensure complete extraction of phenols into the solvent the treatment was repeated.

Sample analysis:

1 ml extract of the sample in five separate test tubes were treated with 0.5 ml of Folin's reagent and after 3 min 1 ml of saturated solution of sodium carbonate was mixed thoroughly. The volume was made upto 15 ml with distilled water and kept in dark at room temperature for 1 hour. The blue colored solution was observed in the colorimeter and the optical densities were noted and compared with the standard curve to obtain the concentration of the phenolic compound. A standard curve was plotted between different concentration of tannic acid and corresponding optical densities. Table shows the results obtained.

RESULTS AND DISCUSSION

As is evident from Tables 1—4 the rate of plant infestation was recorded higher than the leaf infestation. This may be perhaps due to the fact that the adult female fly prefers young, soft and medium sized leaves in shade for egg laying. The number of such leaves is rather limited in a plant and, therefore, fly moves from one plant to another for the completion of egg laying. Hence a higher rate of plant infestation was observed A factor possibly responsible for this behaviour may be the concentration of secondary plant products like tannins (phenolic derivatives), whose concentration increases with the age of the host plant. Phenolic compounds have been shown to be repellant in function (SCHILDKNECHT *et al.*, 1967). This forces the fly to search for younger leaves with low phenolic contents, as is also evident during the course of the present studies. Phenolic compounds when sufficientiy synthesised (concentration rising as the age of the plant) in a leaf undergo esterification with available sugar contents in the plant and from tannins as reported by HASLAM (1966),

TABLE 5. Total Phenolic compound content (average of five replicates) in the leaves of the four host plants of *Liriomyza brassicae* Riley.

Host-plants	Average phenolic content in μg
Brassica campestris L.	190
Pisum sativum L.	176
Tropaeolum majus L.	961
Lathyrus odoratus L.	544

The sugars are phagostimulants (COOK, 1977). The participation of sugars with phenols in the formation of tannins (HASLAM, 1966) tends to reduce the availability of free sugar in older leaves and hence possibly the adult females do not prefer them for egg laying.

Low phenolic contents in the leaves of the host-plants make them

FIGURE 1

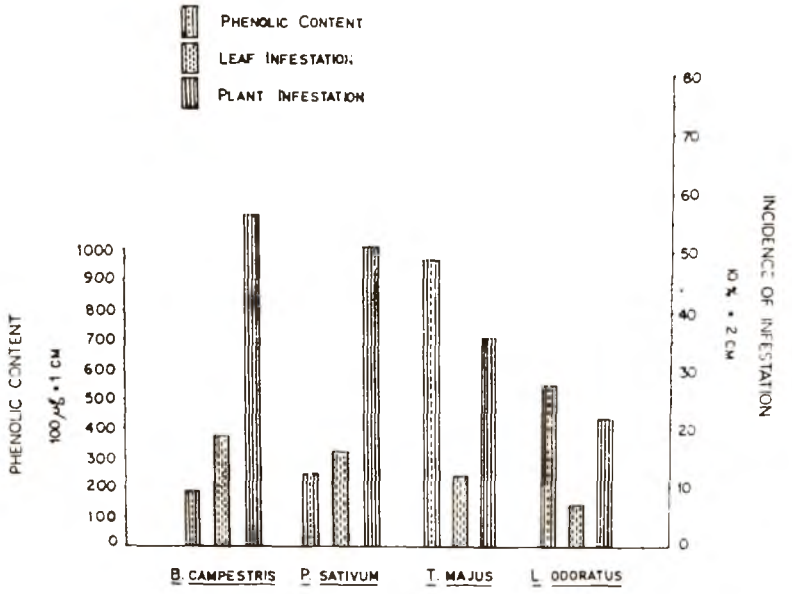

Fig. 1. Relation between phenolic content and insect infestation

more vulnerable to high rate of attack by *Liriomyza brassicae* Riley. The leaves of *Brassica campestris* L. contains the lowest concentration of phenolic compounds and, therefore may act as one of the best preferred plants among the four studied here.

The high rate of infestation by *Liromyza brassicae* Riley on *Tropaeolum majus* L., even with phenolic contents higher than *Lathyrus odoratus* L. is perhaps because of the difference in the leaf texture of the two plants. The leaves of *T. majus* are soft and devoid of any hair growth whereas the leaves in *L. odoratus* are rough to touch, and with profuse hair growth. The characteristic texture of the leaves of *L. odoratus* even with low phenolic content that *T. majus* may make it a more resistant plant among the four host-plants.

The hair growth on the plant body as a resistance factor has been reported recently in an interesting publication by GIBSON (1983) on wild potato, *Solanum berthaultii* which bears a dense layer of sticky hairs on the stem, petioles and the leaves. He also reported the release of a chemical, aphid alarm pheromone (E) Farnesene, on contact. It is possible that *L. odoratus* also may be releasing some repellant chemical from these hairs on the plant body including the leaves.

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DISTRIBUTION OF VARIOUS CASTES IN DIFFERENT PARTS OF THE MOUND OF THE TERMITE, *ODONTOTERMES WALLONENSIS* WASMANN (ISOPTERA: TERMITIDAE)

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Population density * of workers, soldiers and nymphs of the termite, *O. wallonensis* from the different parts of the mound viz., peripheral fungs garden around the royal chamber and from royal chamber itself, and the foraging population density ** from the foraging covered runways on the eucalyptus trees were studied. Percentage of major workers in peripheral fungus garden and foraging covered runways was higher ($p < 0.001$) compared to the other parts of the mound. Percentage of minor workers was more in the fungus-garden around the royal chambet and in the royal chamber ($p < 0.001$) than other parts of the mound. Very high percentage of soldiers was found in royal chamber ($p < 0.001$). Nymphs were found concentrated in the fungus-garden around royal chamber. It is evident from the above results that various castes of this species in different parts of the mound are distributed according to their functional behaviour. The duty of major workers is foraging, construction of the fungus garden and construction of the mound. The duty of minor workers is feeding the royal couple and young ones. Soldiers are meant to guard the foraging workers and the colony including royal couple in the royal chamber.

(Key words: Odontotermes wallonensis, caste distribution, mound, fungus garden, royal chamber)

INTRODUCTION

Total population of various castes and their relative percentages in different species of termites have been studied by HOLDAWAY *et al.* (1935) in *Eutermes exitiosus*, GAY & GREAVES (1940) in *Coptotermes lacteus*, MUKERJEE & MITRA (1949) in *Odontotermes redemanni*, GUPTA (1953) in *O. obesus*, SEN SARMA & MISHRA (1969) in *Microcerotermes beesoni*, BASALINGAPPA (1972) in *O. assumuthi*, MALISSE *et al.* (1975) in *Odontotermes* sp., and AGARWAL (1976) in *O. obesus* and *O. microdentatus*. BLUM (1977) reported that the behaviour of individuals in a colony is often correlated with specific morphological or physiological characteristics which are often emphasized on the individuals within a caste. VEERANNA & BASALINGAPPA (1981) have studied the total population and relative percentages foraging forms of *O. wallonensis* from the covered runways raised on the eucalyptus trees. Since there are no reports regarding the distribution of various castes in different parts of the mound nest except by DARLINGTON (1977) in *Macrotermes subhyalinus*, the present study is undertaken to unravel the same in the termite, *O. wallonensis*.

MATERIALS AND METHODS

Freshly collected royal chamber, fungus garden (from peripheral region and around

* per 100 g unit of fungus garden

** per 10^2 sq cm area

the royal chamber) from the mound nests in the field and the workers and soldiers from covered runways on eucalyptus trees were the materials for the present study. Population density of major and minor workers, and soldiers from the royal chamber was determined by 'whole count' method. Population size of various castes from different parts of fungus garden was made according to the random sampling method (BASALINGAPPA, 1972), and the population of foraging forms from covered runways was made according to sampling unit of 10^2 sq cm area (VEERANNA & BASALINGAPPA, 1981). For comparison of various castes in different parts of the mound, Student 't' test is applied, the p value less than .05 statistically significant.

RESULTS AND DISCUSSION

Population density of workers, soldiers and nymphs of the termite, *O. wallonensis* from foraging covered runways and from different parts of the mound viz., peripheral fungus garden, fungus garden around the royal chamber and royal chamber itself is given in Table 1.

Percentage of major workers in the peripheral fungus garden and foraging covered runways was higher ($p<0.001$) than that of royal chamber and fungus garden around the royal chamber. High percentage of major workers in the above mentioned regions might be due to the foraging, construction and repairing of the mound. According to DARLINGTON (1977) in *Macrotermes subhyalinus*, the peripheral fungus-garden consisted of mainly workers with minor workers slightly outnumbering the major workers, and the soldiers less than 5% of the total. In the trunk galleries, the percentage of major workers was more (70%) than the minor workers and soldiers.

In *O. wallonensis* the percentage of minor workers was high ($p<0.001$) in the royal chamber when compared to other parts of the mound. This high percentage of minor workers might be for the purpose of feeding the royal couple and young ones and for transporting eggs from the royal chamber to fungus garden. High percentage of soldiers ($p<0.001$) in the royal chamber was presumably for guarding the royal couple and to get food from minor workers. Though the royal pair all the time is found well protected in the royal chamber the presence of high percentage of soldiers might be for facing the rare invasion(s) of predatory ants as occur in *O. assumuthi* (VEERANNA *et al.*, 1981). High percentage of nymphal population in the fungus garden around the royal chamber is reasonable because the thousands of eggs laid per day by the large physogastric queen were to be transported from royal chamber and stocked in masses for incubation. It is evident from the above results that various castes of this species in different parts of the mound are distributed according to their functional behaviour.

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TABLE 1. Distribution of workers, soldiers and nymphs in different parts of the mound nest and covered runways of the termite, *Odontotermes wallonensis* Wasmann.

Different parts of mound nest	Major workers	Minor workers	Soldiers	Nymphs	Total	Percentage between			
						Major workers	Minor workers	Soldiers	Nymphs
Peripheral fungus garden	597 ± 75	323 ± 47	115 ± 14	1183 ± 42	2218 ± 150	25.28 ± 1.31	13.11 ± 0.82	4.79 ± 0.23	56.82 ± 1.77
Fungus garden around the royal chamber	520 ± 13	659 ± 32	47 ± 1	10342 ± 435	11573 ± 498	4.65 ± 0.21	5.99 ± 0.38	0.42 ± 0.02	88.94 ± 0.57
Royal chamber	335 ± 53	1002 ± 95	476 ± 44	31 ± 2	1844 ± 175	18.16 ± 1.00	54.28 ± 1.61	25.78 ± 2.23	1.73 ± 0.40
Covered runways	287 ± 18	22	15 ± 3	Nil	323 ± 19	87.93 ± 0.69	7.05 ± 0.50	5.02 ± 0.36	Nil

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USE OF INSECTICIDES APPLIED AS GRANULES IN SOIL FOR CONTROL OF THE MAJOR LEPIDOPETERAN PESTS OF RICE

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(Received 6 May 1984)

Field experiments were conducted in rice fields for three seasons to study the effect of insecticides when applied as granules in soil, on the control of the major lepidopeteran pests of rice viz., stem borer *(Scirpophaga incertulas* Walker), leaf foldr *(Cnaphalocrocis medinalis* Guen), caseworm *(Nymphula depunctalis* Guen) and rice swarming caterpillar *(Spodoptera mauritia* Boisd.). Insecticides tried were carbofuran at 0 5 kg and 1 kg ai/ha, phorate at 1.0 kg and 2.0 kg ai/ha, mephostolan at 0.5 kg and 1.0 kg ai/ha, disulfoton at 1.0 kg and 2 kg ai/ha, quinalphos at 1.0 kg and 2.0 kg ai/ha and chlorodimeform at 1.0 kg and 2 kg ai/ha applied at two occasions at 21 and 45 days after transplanting. Results were assessed based on counts of the affected plant parts and surviving insect populations. Carbofuran at both doses gave control of all the four pest species and the higher dose was significantly superior. Phorate could control only caseworm and swarming caterpillar efficiently. Mephosfolan controlled all the pests except caseworm during second crop season. Disulfoton even at higher dose could control only swarming caterpillar; while quinalphos, at higher dose, controlled caseworm and swarming caterpillar. chlorodimeform at both the doses could control all the pests except caseworm during third crop season and the higher dosage was more efficient.

(Key words: rice, caterpillar pests, control with insecticide granules*)*

INTRODUCTION

The insect pest problems faced by rice crop necessitates application of different types of insecticides at different frequencies. Insecticides in the granular form are applied in soil against the sap feeding pests, as they are easy to apply and highly effective. Many non-systemic insecticides like diazinon, BHC, lindane, carbaryl, endrin and quinalphos and the systemic ones like carbofuran, disulfoton, mephosfolan, phorate, quinalphos and chlorodimeform when applied in granular from show properties ranging from narrow to broad spectrum in their selective insect control effects. Though a number of them are well known for the control of brown plant hopper, insecticides like mephosfolan and chlorodimeform are reported ineffective against it (NARAYANASWAMI & BALASUBRAMANIAN, 1977). Effect of some selected insecticides on control of the major lepidopteran pests of rice, rice stem borer *(Scirpophaga incertulas* Walker), rice leaf folder *(Cnaphalocrocis medinalis* Guen), rice caseworm *(Nymphula depunctalis* Guen) and rice swarming caterpillar *(Spodoptera mauritia* Boisd.) were undertaken, results of which are presented in this paper.

MATERIALS AND METHODS

In these studies field experiments were conducted during the three cropping seasons of

Virippu (May to September) *Mundakan* (September to January) and *Puncha* (January to May) at the College of Agriculture, Vellayani during 1979—1980 using a randomised block design with three replications. The gross plot size was 6×4 m and the plots were alternated with buffer plots of one meter width. Rice seedlings of the variety 'Triveni' of 110 days duration were transplanted at a spacing of 15×10 cm. Separate drainage and irrigation channels were provided for different plots to avoid interplot contamination. The cultural operations recommended for the variety were adopted.

The treatments were carbofuran at 0.5 kg and 1.0 kg, phorate at 1.0 kg and 2.0 kg, mephosfolan at 0.5 kg and 1.0 kg, disulfoton at 1.0 kg and 2.0 kg, quinalphos at 1.0 kg and 2.0 kg and chlorodimeform at 1.0 kg 2.0 kg with two control plots having no insecticide under each replication. The insecticide granules were applied at two occasions, the first 21 days after transplantation (DAT) and second at 45 DAT, coinciding with tillering and boot leaf stage of the crop respectively. The insecticides were broadcast uniformly after mixing the required quantity of granules with 100 g of dry sand and the water level in the plots was mainrained at 2.5 cm approximately throughout the period of experiment.

The treatments were assessed in terms of surviving larval population of rice leaf folder (RLF) rice caseworm (RCW) and rice swarming caterpillar (RSC); dead-hearts and white ear heads were counted for the population of rice stem borer (RSB). Observations were recorded from a unit of one square meter per plot selected at random at weekly intervals. The data were pooled and subjected to analysis of variance after transforming the variables into $\sqrt{x+1}$

RESULTS AND DISCUSSION

Results presented (Table 1) show that carbofuran, mephosfolan and chlorodimeform gave signifcant control of rice stem borer in all the three seasons. Among these insecticides carbofuran at both the concentrations of 0.5 and 1.0 kg ai/ha and chlorodimeform at 2.0 kg ai/ha gave better control than mephosfolan at both the doses and chlorodimeform at the lower dose. Mephosfolan showed in general the same effect at both the doses. Phorate, disulfoton and quinalphos did not give consistent results and appeared to be not effective in controlling the borer.

As regards rice leaf folder also carbofuran, chlorodimeform and mephosfolan were the insecticides which gave significant control. The most effective among these treatments were carbofuran and chlorodimeform at their higher doses; both these at their lower doses were significantly less effective.

Significant and uniform control of rice caseworm was shown by carbofuran and phorate at both the doses and quinalphos at its higher dose. There did not appear to be significant difference in effect between the two doses of carbofuran and phorate.

Rice swarming caterpillar showed significant control by the insecticides carbofuran, phorate, mephosfolan and chlorodimeform at both their doses, the higher dose of each being in general more effective than the lower doses. Disulfoton and quinalphos also indicated significant control at their higher doses.

It will be observed that carbofuran was highly effective in controllng all the four species of caterpillar pests of rice. Its effectiveness against RSB and RLF and against RCW (RAO *et al.*, 1976) was earlier observed in Tamil Nadu. Phorate could give consistant control only of RCW an RSC and of no others. Failure of phorate to control RLF was reported by CHANDRAMOHAN

TABLE 1. Mean population of lepidopteran pests observed per square meter under different insecticide granule treatments during three seasons.

Treatment	ai/ha (kg)	Rice stem borer			Rice leaf folder			Rice caseworm			Rice swarming caterpillar	
		I crop	II crop	III crop	I crop	II crop	III crop	I crop	II crop	III crop	II crop	III crop
Carbofuran	0 5	29.37 a	30.33 b	21.33 a	20.33 b	17.33 a	21.33 b	8.67 a	15.33 b	9.67 b	13.33 b	4.67 b
,,	1.0	22.67 a	13.33 a	15.33 a	10.33 a	5.33 a	8.00 a	6.00 a	6.00 a	9.00 b	9.67 a	1.33 a
Phorate	1.0	48.67	83.67	36.67 b	59.00	222.33	107.00	7.33 a	15.00 b	10.00 b	19.67 b	8.00 b
,,	2.0	39.00	95.00	32.67 b	33.67	139.67	83.67	5.33 a	14.00 b	6.00 b	9.33 a	6.33 b
Mephosfolan	0.5	41.33 b	39.33 b	39.67 b	26.00 b	49.00 b	37.33 b	13.67 b	26.00 b	10.67 b	13.33 b	0 a
,,	1.0	31.67 b	37.23 b	22.67 a	24.33 b	37.67 b	23.00 b	15.33 b	29.67 b	8.00 b	6.67 a	0 a
Disulfoton	1.0	42.33 b	75.00	60.00	36.67	161.67	128.00	19.00 b	28.67	15.00 b	27.33	9.00 b
,,	2 0	60.67	73.67	43.00 b	36.67	117.33	82 00	14.33 b	18.00	18.00 b	13.00 b	10.33 b
Quinalphos	1.0	47.00	77.67	58.00	44.00	158.33	112.67	26.33	14.33 b	13.00 b	26.53	9.00 b
,,	2.0	28.67 a	59.00	40.67 b	33.33 b	146.67	74.00	17.33	6.00 a	10.33 b	20.00 b	6.00 b
Chlorodimeform	1.0	40.67 b	41.67 b	37.66 b	29.00 b	24.00 b	25.67	13.00 b	17.00 b	17.00 b	17.33 b	8.33 b
,,	2.0	19.67 a	14.33 a	22.67 a	15.00 a	9.00 a	13.33 a	20.67 b	17.33 b	14.33 b	13.33 b	9.33 b
Control (untreated)		57.67	72.16	69.83	43.00	178.67	67.00	40.33	23.17	19 33	28.67	20.17

& JAYARAJ (1976) in Tamil Nadu. The erratic control of RSB shown by phorate in these studies agreed with the lack of control reported by MATHAI *et al.*, (1975) and RAI & GOWDA (1976) but was contrary to the significant control observed by JAYARAJ *et al.* (1976) in Tamil Nadu. Control of the caterpillars shown by mephosfolan agreed with the control of RSB and RLF recorded by RAO *et al.* (1976), and others. Chlorodimeform too was effective against all the few species and VELUSAMY *el al.* (1978) had earlier found it effective againt RSB anb RLF in Tamil Nadu. The ineffectiveness of disulfoton and quinalphos observed in these studies had been observed in Tamil Nadu also by JAYARAJ (1976) and HUSSAIN & AZAN (1976) respectively.

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BRIEF COMMUNICATION

EFFECTS OF CYSTACANTHS OF *MONILIFORMIS MONILIFORMIS* (ACANTHOCEPHALA) ON THE TISSUE PROTEINS, HAEMOLYMPH AMINO ACIDS AND FAT BODY HISTOLOGY OF *PERIPLANETA AMERICANA* L.

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(Received 22 May 1983)

Histological changes in the fat body and depletion of total proteins in the fat body and muscle were noticed in *P. americana* infected with the cystacanths of *M. moniliformis*. The decline in tissue proteins showed no parallel changes in the haemolymph amino acids. The significance of the findings is discussed.

(Key words: cystacanths, intermediate host, proteins, fatbody)

Parasitic infection is known to cause various changes in the host tissues such as cellular degradation and depletion of energy reserves (CHENG & SNYDER, 1962). *Periplaneta americana* serves as the host for various helminthic parasites (ROTH & WILLIS, 1960). Studies on the influence of these parasites on its tissue energy reserves appear to be meagre. In the present investigation an attempt has been made to study the effect of infection of the cystacanths of *Moniliformis moniliformis*, an acanthocephalan parasite, on the total protein content of the fatbody, muscle, amino acid composition of the haemolymph, and fat body histology of *P. americana*.

Periplaneta americana infested with 200 to 300 cystacanths were used for the analyses of tissue proteins and haemolymph aminoacids. Fatbody and muscle of the control and infected cockroaches were taken for the total protein determination. The method of LOWRY *et al.* (1953) was followed for proteindetermination. The free amino acids of the heamolymph were determined by single dimensional paper chromatography. Histological preparations of the fatbody from both control and infected specimens were made. The sections cut at 8 μm were stained in the Ehrlich's haematoxylin and eosin.

Table 1 shows the total protein content of the fatbody and muscle of control and infected cockroaches. Both the sexes of the infected cockroches showed a significant decline ($p=0.05$) in the tissue protein levels when compared to normal. The free amino acid composition of the haemolymph revealed no marked difference in both control and infected insects. Histological sections of the fatbody of the infected cockroaches revealed marked changes from that of the control. The fatbody of the infected insects showed vacuolation and depletion of granules in varying degrees.

The parasitic association of the cystacanths of *M. moniliformis* with the

TABLE 1. Mean total protein concentration (μg/100 mg wet wt) in the fat body and muscle of unifected (control) and infected *P. americana* with cystacanths of *M. moniliformis*.

SEX		Control	Infected (above 100 cystacanths)
Male	Fat Body	6728.74 ± 1451.30	2007.00 ± 453.52*
Female		1264.16 ± 239.93	538.41 ± 83.09*
Male	Muscle	2965.47 ± 623.55	532.11 ± 229.70*
Female		1401.50 ± 123.57	224.50 ± 15.24*

* Significant

fatbody, tracheal system, malpighian tubules and haemocytes of its intermediate host *P. americana* has been described by several investigators (SCHNEIDER, 1871; RAVINDRANATH & SITA ANANTARAMAN 1971). However information on the contribution of the tissue constituents in the development of the cystacanths and the histological changes of the fatbody of cockroaches infected with them are only meagre. The present study reveals a significant decline in the total protein content of the fatbody and muscle of both male and female.

Chromatographic analysis of the haemolymph of both control and infected cockroaches revealed the presence of eight amino acids which include isoleucine, methionine, tyrosine, alanine, threonine arginine, histidine and cystine. The percentage composition of the above amino acids revealed no obvious difference in both control and infected insects. Absence of changes in the amino acid composition between the control and infected individuals suggest that the parasite may not have any selective absorption of specific amino acids from its host haemolymph. BARRETT (1981) also reported that the mechanism of amino acid uptake by acanthocephalans is not known, unlike in other helminths. Thus the tissue total protein depletion in the present study may not account for the absence of any change in the amino acids composition of the control and infected cockroaches. It may be that host tissue proteins may be complexed with some other biochemical constituents and taken up by the parasite as has been reported by BARRETT (1981).

Depletion of tissue proteins corroborate the histological changes in the fatbody of the infected cockroaches. The changes in the fatbody of the infected insects such as vacuolation, and disappearance of granules of reserves like proteins and glycogen attribute to the utilisation of them by the developing cystacanths. The significant difference observed in the albumin and globulins of the haemolymph between control and infected cockroaches (RAMALINGAM *et al*, 1982) also lends support to the tissue protein depletion.

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BRIEF COMMUNICATION

A NEW PUPAL PARASITE, *ERETMOCERUS CORNI* HALDEMAN (APHELINIDAE : HYMENOPTERA) ON *DIALEUROLONGA FICI* DAVID AND SUBRAMANIAM (ALEYRODIDAE : HOMOPTERA)

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(Received 8 April 1984)

From field collected specimens of *Dialeurolonga fici* David and Subramaniam during August-September 1983, the parasites emerged from pupae were identified as *Eretmocerus corni* Haldeman (Aphelinidae : Hymenoptera) which forms a new report.

(Key words: Eretmocerus corni, pupal parasite, *Dialeurolonga fici)*

Whiteflies are known as serious pests of agricultural and horticultural crops causing economic injury to the plants by feeding and by transmitting viruses of plant diseases. More than 200 species of natural enemies are reported on Aleyrodids which include 145 species of parasites from Hymenoptera and 13 from Diptera (MOUND, 1965). However, information available on the occurrence of parasites on the genus *Dialeurolonga* is meagre except for a report on the presence of a lepidopteran predator, *Coccidophaga scitula* (Rambur) on *Dialeurolonga africana* (Newstead) (MOUND, 1965).

While studying the biology of *Dialeurolonga fici* DAVID & SUBRAMANIAM (1976) on its host *Ficus religiosa* during August-September 1983, a number of pupae of the insect were found parasitized (Fig. 1). From the parasitized pupae the adults were reared out and their identity established. From the literature available, it was found that no parasitic species has been reported on *D. fici* so far and this forms the first report of its kind.

Earlier reports on *Eretmocerus corni* indicate its occurrence as pupal parasite on six other species of aleyrodids viz. *Bemisia tabaci* (PRIESNER & HOSNY, 1940), *Pealius quercus* (TREHAN, 1940), *Singhius hisbisci* (FULMEK, 1943), *Tetraleurodes corni* (FULMEK, 1943), *Trialeurodes packardi* (THOMPSON, 1950) and *Trialeurodes vaporariorum* (FULMEK, 1943). The present report of *E. corni* as a pupal parasite on *D. fici* forms a new record.

Incidentally, another pupal parasite, belonging to the genus *Encarsia* sp, (Aphelinidae : Hymenoptera) was also observed on *D. fici*.

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BRIEF COMMUNICATION

AN INEXPENSIVE CONE TRAP FOR EMERGING MOSQUITOES UNDER URBAN OR RURAL CONDITIONS

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(Received 26 December 1983)

A simple cone trap was fabricated with the help of discarded X-ray film for capturing mosquitoes emerging from open pit-latrine in and around the human dwellings.

(Key words: cone trap, mosquitoes)

Several authors developed varieties of traps (SERVICE, 1970; 1976; PRITCHARD, 1980), for the estimation of population size and density of mosquitoes. These are conical or box-type either floating or attached to the substrate. To bring down the cost of these traps the present investigators conceived the idea of utilizing discarded X-ray film for mosquito traps useful in trapping emerging mosquitoes from open pit-latrines and ditches beside the human dwellings in urban and rural areas of developing countries like ours. The details are presented in this paper.

The cone with 50 cm diameter at its base and 4 cm diameter hole at apex is made by suitably rolling the X-ray film. A polythene bag of one kg capacity is held in inverted position at the opening at the apex with the help of rubber bands (Fig 1). Provision for aeration for the trapped mosquitoes has been provided inthe polythene bag by punching it with fine holes with the help of a needle. The entire cone

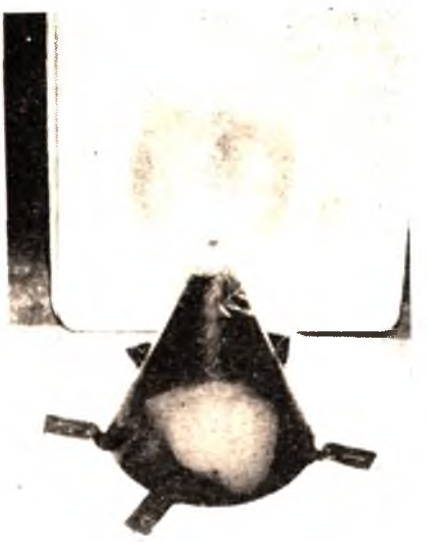

Fig. Cone trap showing the components.

along with polythene bag is provided with five $3 \times 3 \times 1$ cm thermocole blocks. These blocks are attached to the rim of the base of the cone withthe help of X-ray film strips. The weight of the 28 cm tall cone trap so fabricated is only 26 g.

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After confirming that the larvae are present, this cone trap was lowered into an open pit-latrine or a ditch, with the help of plastic thread. Free end of the plastic thread was tied to some object on the bank of the pit-latrine in order to prevent movements of the cage. Pupae gather directly beneath the cone due to the shade provided by the blackness of film used for the cone. When they emerge as adults they will have no other way except to escape into the space in the floating cone and through the opening at the apex of the cone into this transparent punctured polythene bag. After 24 hr the cone trap was hauled out of the the pit latrine or ditch and immediately the porthole at the apex plugged with cotton to prevent any escape of the mosquitoes from the polythene bag. The polythene bag is then removed from the apex of the cone, mouth closed as the rubber string shrinks and placed in the freezer for killing the mosquitoes and then transferred into small injection vials for further analysis. The trapping capacity of this cone trap depends upon the availablity of pupae in that particular pit-latrine or ditch, the diameter of the base of the cone and the size of the poythene bag. This cone trap is used in areas where the open pit-latrines and ditches are situated close to the human dwellings. Pit-latrines may remain open due to the loss or damage of their lids. This inexpensive cone trap is fabricated mainly for analysing the mosquito populations around the human dwellings without much labour in such urban and rural areas.

The present cone trap has been used several times in S. V. University campus for trapping of mosquitoes.

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STUDIES ON THE ACTIVITY OF SOME INSECT POLLINATORS ON JUJUBE (*ZIZYPHUS MAURITIANA* LAMK)

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(Received 26 February 1984)

Incidence and activity of pollen carrying insects were studied on *Zizyphus mauritiana* Lamk. Honey bees and other Hymenopteran insects were more active on upper branches. Houseflies and other Dipteran insects were abundant on middle and lower branches. Honey bees were more efficient pollen carriers while frequency of visits of houseflies to receptive flowers was more.

(Key words: inset pollinators, jujube, *Zizyphus mauritiana)*

Ber or jujube *(Zizyphus mauritiana* Lamk) is an insect pollinated plant. Honey bees, yellow wasps and housefly have been reported as pollinators for *ber* (DHALIWAL, 1975; TEAOTIA & CHAUHAN, 1964). A number of insects were seen associated with these plants during the flowering season at the Central Research Farm, Central Arid Zone Research Institute, Jodhpur. The insects found active in transportation of *ber* pollen, their abundance, frequency of visits, and efficiency as pollinating agents have been studied and reported in this paper.

MATERIALS AND METHODS

The insects visiting *ber* flowers were collected by sudden trapping with polythene bags (25 cm × 45 cm), anaesthetized with ethyl acetate and observed individually for the presence of *ber* pollen, by dipping them in 70% ethyl alcohol. Only those insects which bore *ber* pollen were considered in further studies.

Observations for time of appearance and of maximum activity were made for the major species selected by considering their relative abundance on *ber* flowers. Abundance was defined by the number of insect specimens collected during one hour time each in the morning (8-9 AM), noon (12-1 PM) and afternoon (3-4 PM).

Pollination efficiency of the insects was ascertained in terms of the frequency of visits per hour and the duration of stay or contact with flowers. Since the *ber* flowers remain receptive for pollination only for a period of 24 hours after opening, the freshly opened flowers alone were considered for the studies. For counting the visits 30 cm long portions of upper, middle and lower branches of ber plants were demarcated by tagging them and the visits were recorded by visual observation.

RESULTS AND DISCUSSION

The insects found transfering pollen in *Zizyphus mauritiana* are listed in Table 1. Number of butterflies observed was too low and hence these were omitted in the studies.

Data on the abundance of insect pollinators at different periods of the day are presented in Table 1. Hymenopteran insects except honeybees were not observed in the morning. These were more abundant around noon. In the afternoon also their density was low. Dipteran insects though present in the morning, were more abundant around noon and afternoon.

TABLE 1. Insect pollinators of *Zizyphus mauritiana* Lamk. and their relative abundance.

Insect	No. of specimens collected			Mean/Hour
	Morning (8–9 h)	Noon (12–13 h)	Afternoon (15 16 h)	
ORDER DIPTERA				
Fam. Calliphoridae:				
Chrysomyia rufifacies	4.67	3 67	9.33	5 89
Fam. Muscidae:				
Musca domestica L.	18.67	47.00	22.33	29.23
Fam. Otitidae:				
Physiphora aenea (Fabr.)				
Physiphora demandata (Fabr.)	16.67	55.33	34.00	35.33
Fam. Sarcophagidae:				
Sarcophaga sp.	7.33	8.33	5.67	7.11
Fam. Syrphidae				
Allobaccha sapphirhina Wieldmann	3.00	2.00	7.33	4.11
Eristalinus sp.	4.33	9.00	12.33	8.55
ORDER HYMENOPTERA				
Fam. Apidae:				
Apis indica L.	7.00	44.67	18.33	23.33
Apis sp.	1.33	3.33	—	1.55
Fam. Eumenidae:				
Delta campaniforme esuriens F.	—	6.33	2.67	3.78
Fam. Halictidae:				
Nomioides variegatus (01)	2.33	6.33	2.67	3.78
Fam. Sphecidae:				
Chalybion bengalense (Dahlbom)	—	6.67	1.67	2.78
Oxybelus lamellatus Olivier	2.67	5.33	4.33	4.11
Philanthus basalis F. Smith	—	6.67	3.33	3.33
Sceliphron madraspatanum pictum (F. Smith)	4.67	6.33	1.33	4.11
Fam. Scolidae:				
Campsomeriella collaris (Fabr)	—	8.33	2.33	3.55
Fam. Tiphidae:				
Iswara luteus Westwood	—	4.67	1.67	3.11
Fam. Vespidae:				
Vespa orientalis Fabr.	—	4.33	1.67	2.00

TABLE 2. Frqeuency of visit of major insect pollinators of *Zizyphus mauritiana* Lamk at different periods of the day.
(Means of the observations for three weeks)

S. N.	Insect		visits per hous			Mean	No. of respective flowers	Visits per respective flower
			8—9 h	12—13 h	15—16 h			
1.	*Apis indica*	U*	14.33	46.33	31. 0	30.55	11	2.78
		M	12.67	43.67	27.33	27.89	9	3.10
		L	6.33	34.00	15.00	18.44	8	2.30
2.	*Chrysomyia*	U	3.67	4.67	6.33	4.89	6	0.82
	rufifacies	M	6.67	4.00	6.67	5.78	8	0.72
		L	13.33	17.67	20.00	17.00	8	2.13
3.	*Eristalinus*	U	7.33	4.67	6.33	6.11	6	1.02
		M	18.33	17.67	20.00	19.33	8	2.42
		L	17.33	22.00	34.33	24.55	6	4.09
4.	*Musca*	U	12.33	19.00	26.67	19.33	8	2.42
	domestica	M	52.33	58.00	37.33	49.22	8	6.15
		L	87.67	86.33	104.00	92.67	6	15.45
5.	*Physiphora*	U	24.33	27.33	31.67	27.78	9	3.09
		M	37.33	42.33	47.33	42.44	7	6.06
		L	49.33	68.67	61.67	59.89	7	8.56
6.	*Sarcophaga*	U	2.67	2.33	7.33	4.11	8	0.51
		M	14.33	17.00	13.33	14.89	9	1.65
		L	8.33	14.67	12.67	11.89	6	1.98
	SEM±	U	0.76	1.69	0.84			
		M	3.61	2.97	1.74			
		L	2.78	2.70	2.21			
	CD ($p=0.5$)	U	2.39	5.34	2.65			
		M	11.38	9.36	5.49			
		L	8.75	8.50	6.96			

*U = Upper branch (30 cm portion)
M = Middle branch (,,)
L = Lower branch (,,)

Frequency of visit of the major pollinators is shown in Table 2. Hymenopteran insects were dominant on upper branches whereas the dipterans were found more active at the lower and middle branches. Houseflies, honey bees and Otiids were more frequent visitors. Of these, honeybees and houseflies were largely responsible for the transmission of *ber* pollen. The Otitids hough were more frequent visitors, did not carry much of pollen. DHALIWAL (1975) and TEAOTIA & CHAUHAN (1964) also had reported honeybees and houseflies as principal pollinator insects for *Zizyphus mauritiana*. Whereas *Chrysomyia, Eristalinus, Physiphora* and *Sarcophaga* visited all the flowers regardless of their receptivity, honey bees and houseflies visited mostly the receptive flowers, although older flowers were also visited.

Most of the insects, except housefiy, appeared after 8 AM. Maximum activity of honeybees was recorded between 11.30 AM to 3.15 PM. TEAOTIA & CHAUHAN (1964) had reported similar observations. Houseflies and other Dipteran insects which were more abundant on lower and middle branches, exhibited maximum activity in the afternoon. Honeybees were found to be active on upper branches as well. Of all the insects observed, housefly was found to be active for maximum time in the day (7.30 AM to 6.30 PM) whereas the honeybee's span of daily activity was the shortest (8.30 AM to 4.15 PM).

The flowers opening in the morning time were exposed more to houseflies and therefore mostly got pollinated by them. Contribution of honeybees was more in pollination of cultivars like Gola and Mundia where anthesis occurred around 12-13 h (VASHISHTHA & PAREEK, (1979).

Honeybees were found to be more efficient carriers of pollen, but their activity was restricted to a limited time in the day and the number of visits per flower (Table 2) was also less. In contrast, the activity of houseflies was spread to a longer duration and their frequency of visit was also more. However the time of actual contact or stay on the flowers was very short. Flowers opening early in the season were exposed mostly to houseflies, since the honeybees appeared only when full bloom set in.

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BRIEF COMMUNICATION

OBSERVATIONS ON THE MITE *NEOCYPHOLAELAPS INDICA* EVANS AND ITS RELATIONSHIP WITH THE HONEY BEE *APIS CERANA INDICA* FABRICIUS AND THE FLOWERING OF *EUCALYPTUS* TREES

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Mites of the genus *Neocypholaelaps* (Family: Ameroseiidae) have been found associated with the inflorescence of some trees and also with certain hymenopterous genera like *Apis* and *Trigonia*. These mites are observed mostly on the thorax and sometimes on abdomonal segment of bees Population of the mite infested bees increased during early autumn and also during late winter (July-August and January-February respectively). These periods coincide with the minimal availability of *Eucalyptus* flowers. The number of mites per individual infested bee ranged from 1-400. The hosting has been observed mainly on forager bees. 99% of the mites found on a bee are females, though larvae, deutonymph and males (described elsewhere) have also been located. Visually there has been no effect on the colony of the honey bees attributable to the association of these mites. Mites were found roaming about on the floor board and on the brood combs of the hives. But super combs (the combs in the portion of the bee-hive used for storing honey) are very rarely observed to contain not only freely roaming mites but also mite infested bees.

These mites have been found to occur on inflorescence of three species of *Eucalyptus* namely *E. globulus*, *E. eugenoides* and *E. ficifolia*, but is more common in *E. globulus* probably due to the large size of the inflorescence and longer period of nectar secretion and pollen availability. Stages of the mites from egg to adult have been found on the inflorescence The eggs are laid at different places on the inflorescence. In *E. globulus* eggs are found on the exterior of the ridge of the hypantheal cup and also at the base of the stamens. In *E. eugenoides* and *E. ficifolia* they are laid only at the base of the stamens. It is quite obvious that *Eucalyptus* inflorescence is a feeding as well as breeding ground for the mites. In the absence of *Eucalyptus* inflorescence, bee hives are the only source for *Eucalyptus* pollen as the bees store them. The life of the *Eucalyptus* flower is for about a week and during that period probably the life historv of the mites gets completed. The bees come to the inflorescence when the nectar secretion starts, and the mites alight on the inflorescence and start laying the eggs. The eggs hatch and the life history of

the mites start. In the mean time the *Eucalyptus* pollen also matures. By the time the life history of the mite is completed the adult mites ascend upon the stamens to feed on the pollen grains. When the bees return to the blossom for the collection of pollen the mites get themselves attached to the bees and return to the hive. This process is repeated until such time the inflorescence is in blossom. At this time the number of mites attached to the bees leaving the hive is comparatively less. But when the blossom is on the wane the mites get themselves attached to the bees and return to the hive. Most probably they live in the hive till the next *Eucalyputs* flowering starts. These mites are predated on by the pseudoscorpions *Ellingsenius indicus,* which are also found in the bee hives.

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BRIEF COMMUNICATION

NEW RECORDS OF SOIL ORIBATID MITE FROM TRIPURA

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The first oribatid mite in India was described by Pearce (1906) The total number of oribatid species known from India now stands at 163. These belong to 91 genera and 47 families. In spite of their ecological importance this group of mite received little attention in the North-Eastern region of India. Only 10 species belonging to 7 genera are known from this region through the investigations of GHOSH & BHADURI (1978) & MISRA *et al.* (1982), who have worked in Nagaland and Manipur respectively. Till date there is no authentic record of any oribatid species from Tripura.

The present communication records 15 species of soil inhabiting Oribatids including their distribution in India. The records are based on the examination of soil samples, collected from localities mentioned below. All are new records from the state and species marked with asterisks (*) are new record from India.

Collection sites

1) Sepahijala Biocomplex
   i) Rubber plantation:-19-2-82 (SR_1), 20-3-82 (SR_2), 19-4-82 (SR_3). ii) Virgin forest:-19-2-82 (SF_1), 20-3-82 (SF_2) 19-4-82 (SF_3).
2) Agartala
   i) From canopy base of Jack fruit tree:-20-4-83 (JFT_1), 12-5-83 (JFT_2).
   ii) From the base of *Caesalpinia pulcherrima* SW: 19-7-83 (CP).
3) Anandanagar : Wasteland (AN).

LIST OF ORIBATID SPECIES AND THEIR DISTRIBUTION IN INDIA

1) *Annectacarus longisetosus* Bhattacharya, Bhaduri and Raychaudhuri 1974, 2 females, (JFT_2). : West Bengal.

2) *Cryptacarus dendrisetosus* Bhattacharya, Bhaduri and Raychaudhury 1974, 2 females, (SF_1). : West Bengal.

3) *Haplacarus foliatus bengalensis* Bhattacharya, Bhaduri and Raychauduri 1974, 3 females, (JFT_2) : West Bengal, Nagaland.

4) *Javacarus kuhnelti* Balogh 1961, 2 females, (JFT_1) : West Bengal, Orissa.

5) *Paulianacarus foliatus* Mandal and Chakraborty 1982, 1 female, (AN) : West Bengal.

6) *Epilohmannia pallida pacifica* Aoki 1965, 2 females, (SF_3). : West Bengal, U. P, Orissa.

**7)* *Malaconothrus ramensis* Hammer 1966, 1 female (JFT_1).

8) *Berlesozetes auxiliaris* (Grand jean, 1936), 1 female, (SF_1) : West Bengal, Orissa.

*9) *Striatoppia opuntiseta* Balogh and Mahunka 1968, 1 female, (SF_3).

10) *Sheloribates praeincisus interruptus* Berlesi 1916, 2 females, (JFT_1) West Bengal.

*11) *Sheloribates fimbriaioides* Hammer 1977, 1 female (SR_2).

12) *Rostrozetes foveolatus* Sellinick 1925, 2 females, (JFT_2) : West Bengal.

13) *Pilobatella berlesi* Bhattacharya and Banerjee 1979, 1 female (JFT_2) West Bengal.

*14) *Paralamellobates ceylanicus* (Ousemans, 1915), 2 females, (SF_1), 2 females, (JFT_1).

15) *Lamellobates palustris* Hammer 1958, 1 female, (JFT_1) : West Bengal.

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REPORTS AND NEW RECORDS

SOME OBSERVATIONS ON THE PESTS OF WINGED BEAN IN ANDAMANS

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This is the first report of *Spodoptera litura* Fab. infesting winged bean. Marked variation in level of infestation to different cultivars was noticed in Andaman. Grasshopper and aphid were recorded as minor pests.

(Key words: Spodoptera litura, winged bean, new record, varietal susceptibility)

Winged bean *Psophocarpus tetragonolobus* recently introduced at Port Blair, Andamans thrives well there. Among the insects infesting the crops, caterpillars of *Spodoptera litura* Fab. (Noctuidae) were found to be causing serious damage to the crop. The larva feeds on the tender leaves causing maximum damage from October to February. Among the 16 cultivars under trial, 3 were damaged severely, 4 moderately and 9 were almost free from infestation. This is a new record of this pest on winged bean. The pest could be controlled with sprays of 0.04 percent endosulfan.

The other species of insects found on the plants were the grasshoppers *Hieroglyphus banian* Fab., *Chrotogonus trachypterus* Blanch. and aphids *Aphis gossypii* Glover. They were only minor pests.

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LABORATORY STUDIES ON SUPERPARASITISM IN *CHELONUS BLACKBURNI* CAMERON (BRACONIDAE : HYMENOPTERA)

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The various parameters under superparasitism were determined by exposing 50 eggs of *Corcyra cephalonica* (Stainton) to variable number of females of *Chelonus blackburni* Cameron. The progenies produced were 23.5, 28.6, 11.1, 2.8, 0.6 and 0.9 in the treatments having 1, 2, 4, 6, 8 and 10 parasitoid females respectively. The number of unparasitized hosts in the respective treatements were 18.8, 9.2, 7.6, 8.6, 8.2 and 11.0 as compared to 35.5, in the control. The number of non-viable hosts in the corresponding treatments were 7.3, 10.6, 28.9, 38.3, 39.8 and 35.8 as compared to 14.3 in the control. The incidence of parastitism varied from 62.0 to 98.0 in the various treatments. The number of viable hosts were maximum in the control and treatment having one female. There was no difference in body size in the progeny resulting from 1, 2 and 4 female treatments. The longevity was studied of 1, 2, 4 and 6 female progeny and longevity was significantly more in one female treatment.

(Key words: Chelonus blackburni, superparasitism *Corcyra cephalonica)*

Chelonus blackburni Cameron is an exotic egg-larval parastitoid. It has given promising results for the control of cotton bollworms in USA and India (BRYAN *et al.* 1973; LEGNER & MEDVED, 1981; SWAMIAPPAN & BALASUBRAMANIAN, 1980). This parasitoid was introduced in Punjab against cotton bollworms. Very little information is available about the intraspecific relationship of this parasitoid and such information is always useful in mass multiplication programme of any parasitiod. So it was considered necessary to study the effect of superpararasitism in this parasitoid and the results are presented in this paper.

MATERIAL AND METHODS

The adults of *C. blackburni* Cameron were obtained from Biological Control Laboratory, Department of Entomology, Punjab Agricultural University, Ludhiana for experimental work. The eggs of *Corcyra cephalonica* (Stainton) were used as host. The superparasitism is an important phenomenon in the field of biological control and plays a great role in the multiplication programme of the parasitoids. The adults produced from the superparasitized host are usually weak, having small size and short life and sometimes the surperparasitized host fail to hatch. So keeping this in view the progeny of variable number of parasitoids on fixed number of host was studied. The oviposition rate per host and viability was also studied to determine whether the parasitoid can discriminate between a parasitized and unpasasitized host. The size and longevity of a progeny produced by variable number of parasitoids was also studied. The following experiments were laid out to determine the effects.

(a) *Progeny of variable densities of C. blackburni females*

The progeny of variable namber of *C. blackburni* females, i.e. 1, 2, 4, 6, 8 and 10 per

50 eggs of *C. cephalonica* were studied. For each treatment, the parasitoid females (24 h old) were kept separately in glass-chimneys. A cotton swab soaked in 30 per cent honey solution was given as food to the adult parasitoids. In each glass chimney, 50 freshly laid host eggs were mounted sparsely (10 cm × 4 cm) using gum and were exposed to 24 hours old females for 24 hours. An unexposed card with 50 eggs was kept as control. The eggs exposed under each treatment and that of control were reared singly in glass vials (10 cm × 2.5 cm). On hatching the host larvae were reared on ground Jowar in glass tubes. The number of adult parasitoids, adult of *Corcyra cephalonica* emerged and non-viable host in each treatment were recorded. The expriment was replicated thrice.

(b) *Oviposition rate of variable densities of C. blackburni females*

The oviposition rates of variable numbers of *C. blackburni* females, i.e. 1, 2, 4, 6, 8, and 10 per 50 hosts were determined. In each treatment the host eggs were exposed for 24 hours as per procedure mentioned in the previous experiment.

The host eggs of all treatments were dissected in a drop of saline water on a glass slide by mashing them gently with a cover slip. The dissected host eggs were observed under binocular microscope in order to count the number of parasitoid eggs in each case. The per cent parasitism, total number of parasitoid eggs, number of eggs laid by one female and mean number of parasitoid egg/host were also observed.

(c) Viability of *C. cephalonica* eggs parasitized by variable densities of *C. blackburni* females

The effect of parasitism by variable numbers of parasitoid females, i. e. 1, 2, 4, 6, 8 and 10 on the viability of eggs of *C. cephalonica* was determined in each case. The host eggs were exposed for 24 hours at 50 per treatment, as described earlier. One similar egg card was kept as control.

The parasitoid egg-cards of all treatments and of control were kept separately in specimen tubes (15cm × 2.5cm) for incubation. The number of eggs hatched in each treatment was recorded. The experiment was replicated thrice.

The data of the three experiments were analysed statistically.

(d) *Size and longevity of individuals of progeny resulted from variable densities of females of C. blackburni*

The body sizes, i. e., length and breadth of the progeny resulted from 1, 2 and 4 females per 50 host eggs were determined. Out of the parasitoid progeny produced in each treatment, the ten individuals were anaesthetized with chloroform and their sizes were measured. The measurements were taken with the help of binocular microscope and an ocular micrometer. The data obtained were analysed statistically. The longevity of the progeny resulted from 1, 2, 4 and 6 females per 50 hosts was also determined. The first ten individuals of the progeny produced in each treatment were held together in a glass chimney (500 cc). The open ends of the glass chimney were covered with voile cloth. Each parasitoid was provided with fresh food swab daily until death. The longevity of each parasitoid was recorded and the data were analysed satistically.

RESULTS AND DISCUSSION

(a) *Progeny produced by variable densities of females of C. blackburni*

The progenies of variable numbers, i.e. 1, 2, 4, 6, 8 and 10, females of *C. blackburni* was determined by exposing 50 eggs of *C. cephalonica* for 24 hours in each treatment. The data presented in Table 1 revealed that maximum number of parasitoid progeny were produced in the treatment where two females were employed. It was followed by the treatments having one and four females, respectively. The treatment having one female per 50 eggs was on a par with the treatments having two females per 50 eggs and both the treatments were significantly better than all the other treatments. But the progeny test revealed that the number of progeny produced by two females was not double of that produced by one female. This indicated that superparasitism occurred even

TABLE 1 Progeny produced by variable densities of females of *Chelonus blackburni* at 26.0 ± 1.7°C and 60.6 ± 6.7 per cent relative humidity by employing eggs of *C. cephalonica* as host.

No. of parasitoid females/50 eggs	*No. of parasitoids produced	*No. of *C. cephalonica* moths produced	*No. of non-viable hosts
1	23.5(4.95)[a]	18.8(4.45)[a]	7.3(2.88)[a]
2	28.6(5.43)[a]	9.2(3.19)[a]	10.6(3.41)[a]
4	11.1(3.48)[b]	7.6(2.93)[a]	28.9(5.48)[b]
6	2.8(1.95)[c]	8.6(3.10)[a]	38.3(6.27)[b]
8	0.6(1.28)[c]	8.2(3.03)[a]	39.8(6.38)[b]
10	0.9(1.38)[c]	11.0(3.46)[a]	35.8(6.06)[b]
0 (control)		35.5(6.05)[b]	14.3(3.90)[a]
Errors M S	0.52	0.56	0.41
Standard error	0.42	0.43	0.36
F-test (F=0.05)	significant	significant	significant

*Average of 3 replicates. Figures in parentheses are $\sqrt{n+1}$. Figures followed by a common letter in a given column do not differ significantly ($P=0.05$) as per Duncan's multiple range test

when two females were employed per 50 hosts consequently reducing the number of parasitoid progeny. The reduction in the number of parasitoid progeny was quite significant when four or more females were employed. It conforms to the findings of PAUL *et al.* (1980), that no progeny was produced when number of host eggs per female was five or below.

A maximum of 28.6 parasitoids were produced when two females were employed per 50 hosts, i.e. parasitoid host ratio was 1:25. But PAUL *et al.* (1980) reported that a maximum of 35 parasitoids were produced when 90 hosts were exposed to single parasitoid female.

In the same experiment the number of adult moths, of *C. cephalonica* were also determined. The maximum number of moths were produced in the control followed by the treatment having one female, the number of moths in the latter case being almost half as compared to control. All the treatments, i.e. treatments having 1, 2, 4, 6, 8 and 10 females, were on a par with each other and significantly different from control.

The number of non-viable eggs of *C. cephalonica* was also recorded in the same experiment. The minimum number of non-viable hosts was observed in the treatment having one female, but it was not significantly different from the treatment having two females and control, which followed in turn. The number of non-viable hosts was significantly higher in other treatments, i.e. having four or more females, which were on a par with each other indicate the occurrence of superparasitism.

The reduction in the viability of *Spodoptera exigua* Hubner and *Heliothis zea* (Boddie) eggs due to superparasitism by *C. blackburni* has also been reported by JACKSON *et al.* (1979). The present investigation also confirms this phenomenon.

(b) *Incidence of parasitism and rate of oviposition by variable densities of females of C. blackburni*

The incidence of parasitism and the rate of oviposition by variable numbers, i. e., 1, 2, 4, 6, 8 and 10 females of *C. blabkburni* were determined by dissecting eggs of *C. cephalonica* exposed in each treatment for 24 hours. The data presented in (Table 2) revealed that the incidence of parasitism of the host eggs increased as the density of females was increased. A minimum of 62.0 per cent parasitism was observed in the treatment where only one female was employed. The percentage parasitism was 74% and 78% in the treatment having two and four females, and it was above ninety where number of females was six or more. The cent per cent parasitism was not achieved even in 10 female treatment. The increase in the incidence of parasitism in the successive treatments was not proportionate to the increase in the number of parasitoid females employed.

The mean number of parasitoid eggs deposited per host in different treatments was also determined in the same experiment. It was observed that a minimum of 1.6 eggs were deposited per host egg in the treatment having one parasitoid female per 50 eggs. When two females were employed the number of eggs deposited per host egg was 2.8. The maximum number of parasitoid egg, i. e. 10.4 was deposited per host egg in the treatment having maximum number of parasitoid females, i. e. ten females. The number of parasitoid eggs deposited per female did not vary much with change in the number of parasitoid employed. This indicated that in all the treatments, each female might

TABLE 2 Incidenee of parasitism and rate of oviposition by variable densities of females of *C. blackburni* by dissection method 26.4°C and 70 per cent relative humidity.

No. of parasitoid females	No. of host eggs parasitized	parasitism in percentage	Total no. of parasitoid eggs	Mean no. of eggs laid by one female	Mean no. parasitoid eggs per host egg	Range of eggs laid in a host number
1	31	62.0	51	51.0	1.6	1–3
2	37	74.0	104	52.0	2.8	1–6
4	39	78.0	215	53.8	5.5	1–14
6	48	96.0	320	54.0	6.7	1–14
8	48	96.0	440	55.0	9.1	1–21
10	49	98.0	501	50.1	10.4	1–26

All the eggs exposed to the parasitoids were dissected.

have laid almost the same number of eggs irrespective of the number of host egg. It is concluded that the females do not retain eggs and oviposit even on the parasitized hosts repeatedly.

In all the treatments, even where the incidence of parasitism was not cent per cent, more than one parasitoid eggs were deposited in a host. Some host eggs received two or three parasitoid eggs while more than one-third, i. e. 35 per cent, of the hosts remained unparasitized in the treatment having one female per 50 eggs. This indicated that the parasitoid females were unable to discriminate between the eggs unparasitized and parasitized by themselves or other females of their own species, consequently oviposting on the latter repeatedly, re-recording superparasitism.

(c) *Vaibility of C. cephalonica eggs parasitized by variable densities of females of C. blackburni*

The viability of *C. cephalonica* eggs, parasitized by variable numbers of parasitoid females, i. e, 1, 2, 4, 6, 8 and 10 females, and of unparasitized eggs, i. e. control, was determined. The data (Table 3) revealed that the maximum number of host eggs hatched in the control, followed by the treatment having one parasitoid female, there being no significant difference between the two. The treatment having two and four parasitoid females followed in turn, both differing significantly from all other treatments. The treatments having 6, 8, and 10 parasitoid females were on a par with each other but inferior to all other treatments. The maximum number of non-viable host eggs was observed in the treatment where 10 females were employed. It was followed in turn significantly by treatments, having 6 and 8 females, both being on a par with each other. The treatments having 4, 2, 1 and 0 were next in increasing order of non viable eggs and the control recorded minimum number of non-viable eggs.

TABLE 3 Viability of *Corcyra cephalonica* eggs exposed to variable densities of females of *C. blackburni* at 27.0 ± 0.72°C and 70.0 ± 0,78 per cent relative humidity

No. of parasitoid females/50 eggs	*Mean no. of eggs hatched	Mean No. of non-viable eggs
(Control	40.83(6.39)[a]	8.82(2.97)[a]
1	33.41(5.78)[a]	16.08(4.01)[b]
2	21.94(4.79)[b]	27.00(5.19)[c]
4	13.84(3.72)[c]	35.88(5.99)[d]
6	7.29(2.70)[d]	42.12(6.49)[e]
8	7.62(2.76)[d]	42.25(6.50)[e]
10	5.29(2.30)[d]	44.49(6.67)[f]
Error M S	0.14	0.18
Standard Error	0.215	0.245
F-test (F=0.05)	Significant	Significant

*Average of 3 replicates. Figures in parentheses are √n. Figures followed by a common letter in a given column do not differ significantly ($P=0.05$) as per Duncan's multiplt range test

Though the viability of host-eggs was reduced even when only one female was employed, the significant reduction in the viability occurred only when two or more parasitoid females were employed, since treatments of the one female and control were on a par with each other. This revealed that the superparasitism occurred in the treatment having two females. The effect of superparasitism was quite pronounced when the number

of parasitizing females was 6 or above per 50 hosts. Similarly the number of non-viable eggs increased with the increase in the number of parasitoid females. The females also failed to discriminate between the parasitized and unparasitized host.

JACKSON *et al.* (1978) reported that 1 to 2 eggs of *C. blackburni* did not prohibit normal hatching of eggs of *P. gossypiella* but the superparasitized eggs collapsed. The reduction in the viability of *S. exigua* egg has been reported by JACKSON *et al.* (1979).

(d) *Size and longevity of individuals of the progeny resulted from variable densities of females of C. blackburni*

The body size, i. e. length and breadth, of offspring produced from treatments having 1, 2 and 4 females per 50 hosts was determined. The mean length of the body of the adult in the respective treatments was 3.4 mm and 3.3 mm and the respective breadth was 1.1 mm in all the treatments (Table 4). Both length and breadth of the body in the three treatments were on a par with each other. It implied that parasitism by varied densities of females had no significant effect on the size of the progeny produced.

The longevity of progeny produced by 1, 2, 4 and 6 females per 50 hosts was determined. The data (Table 4) revealed that the maximum mean longevity of 22.6 days was observed in the treatments having 1 female. The mean longevity of the progeny in the treatments having 6, 4 and 2 females was 18.4, 17.9 and 14.6 days respectively. The longevity of progeny in the treatment having one female was significantly more than that in the treatment having two females. The treatments having four and six females were on a par with one another.

TABLE 4 Size and longevity of individuals of the progeny resulted from variable densities of females of *Chelonus blackburni* at 26.0 ± 1.84°C and 65.0 ± 7.35 per cent relative humidity.

No. of parasitoids/ 50 hosts	*Body size of progeny (mm)*		Longivity of progeny (in day)
	Length	Breadth	
1	3.4(1.84)	1.1(1.04)	22.6(4.76)[a]
2	3.4(1.84)	1.1(1.04)	14.6(3.82)[b]
4	3.3(1.81)	1.1(1.04)	17.9(4.24)[b]
6	Not observed	Not observed	18.4(4.29)[b]
Standard Error	—	—	0.26
F-test (F=0.05)	Non-significant	Non-significant	Signigicant

Figures in parentheses are $\sqrt{n}$. Figures followed by a common letter in a given column do not differ significantly ($P=0.05$) as per Duncan's multiple range test. The figures are based on 10 individuals in each case.

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